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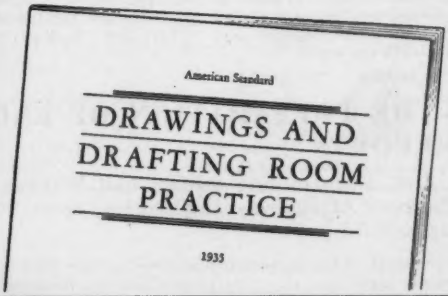


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# THE JOURNAL OF ENGINEERING EDUCATION

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## SOME TRENDS IN THE HIGH SCHOOL

By S. B. EARLE, Vice President of the Society

Not so many years ago there was rather general criticism that the high schools were operated chiefly to prepare students for college. With the great increase in number of the schools and in the students attending them, and also because of the change in social and economic conditions, the curricula have been changed to try to meet the needs of the many who never attend college, by the addition of more vocational and informative courses with the idea of better preparing them for life. At the same time, as far as practicable, the proper courses have been offered to those who expect to attend a college. What I shall say in regard to some of the changes refer particularly to the schools in South Carolina, but no doubt apply equally well to other sections of the South, and possibly to the country at large.

The physical plant of the high schools has greatly improved in the last few years. Good brick buildings of modern design have been built nearly all over the state and better equipment has been added in nearly all cases. The qualifications of the teaching personnel has also greatly improved, practically all of our teachers having the necessary training in subject matter and many of them courses in education in addition.

Arithmetic seems to be almost wholly confined to the first half year of the high school though there are a few who give Arithmetic for a half year during the fourth year. Algebra is given by a large majority for one half year during the first year, all of the second year and by nearly half of the high schools for half of the fourth year. Plane Geometry is offered by almost all in the third year, though by a few in the fourth. Solid Geometry is offered by only about 10 per cent and when offered is given in the fourth year. Latin shows a marked decline, being offered by a much smaller number of schools now than five years ago, and being elected by a much smaller number of students. Five years ago Latin was offered by 77 per cent, 81 per cent, 28 per cent and 18 per cent respectively for the four years while last year it was offered by 32 per cent, 41 per cent, 16½ per cent, and 10 per cent. The number of students electing Latin decreased almost in the same proportion as the schools offering it. French is given by a large majority and is offered in the third and fourth years. The number of schools offering and the number of students electing French has changed little in the last five years, though it does show a little decline.

General Science is given by almost all of the schools and generally in the first year and is taken by about 80 per cent of the students. Biology is offered largely in the second year to about 66 per cent of the students. Chemistry is offered by 21 per cent in the third year and 12 per cent in the fourth year and is elected by 20 per cent and 7 per cent respectively. There has been practically no change in this during the last five years. Physics is offered by 6 per cent in the third and 23 per cent in the fourth, a slight increase, though the number of students electing Physics has not changed very materially.

Physical Geography is given in the second, third and fourth years and shows a slight decline in both the number of schools offering and the students taking it. History is offered all four years but the trend seems to be toward concentration toward the last three years. Forty per cent take General History in the second year, 15 per cent U. S. History in the third and 80 per cent U. S. History in the fourth.

There has been a considerable amount of consolidation of the small high schools, which should tend to improve the work very materially, by making it possible to have better equipment and better teachers and also a sufficient number of students to warrant the giving of many courses which could not be offered in the small high school. There are still, however, a number of relatively small high schools, which, because of the lack of equipment and teaching personnel cannot offer such courses as Chemistry, Physics, etc. From the standpoint of those students going to college I believe therefore it would be better under the existing conditions for the students not to elect these subjects but to defer them until they go to college. It would be better for them to take Latin, French, History or other subjects of this nature, as the courses in college are necessarily planned for those who have had no previous training in these subjects. I believe it would also be better for Algebra to be given in the second or third year and all of the fourth. The student would be somewhat more mature by this time as well as being nearer the time of entrance to college. Some of the more general subjects might be given a little earlier in order to reach more of those who drop out before the third and fourth years.

What we need to do is to keep in closer touch with the high schools so that particularly those students who expect to enter the Engineering School will know better what to elect in the high school. We should try to see that these courses are offered by all the high schools, or if this is impossible, that the students be shown the necessity of attending another high school for a year or so where they are offered.

While consolidation of the schools has helped the situation materially, we must guard against the offering of too many courses of a purely informational nature, remembering that whether we are trying to fit the students for life or for college, our aim should be to teach them to think and enough courses leading to this end should remain in the curricula. I hope the work of the E. C. P. D. will improve the relationship between the high school and the college as the years go by.

## ENGINEERS' COUNCIL FOR PROFESSIONAL DEVELOPMENT BEGINS INSPECTION OF ENGINEERING COLLEGES

By H. P. HAMMOND

On November 21st the Committee on Engineering Schools of Engineers' Council for Professional Development met at New York City for the purpose of launching its work of inspection of engineering colleges. This work is being done under authorization to function as the accrediting agency of the several constituent groups comprising E. C. P. D.: American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers, American Institute of Electrical Engineers, American Institute of Chemical Engineers, the Society for the Promotion of Engineering Education, and the National Council State Board of Engineering Examiners.

Stevens Institute of Technology, Hoboken, New Jersey, was inspected on November 21, for the purpose of appraising its curriculum in General Engineering; and The School of Engineering of Columbia University was visited on November 22, for the inspection of curricula in Chemical, Civil, Electrical, Mechanical, Metallurgical, Mining, and Industrial Engineering, and in Mineral Dressing. As a result of these inspections, together with study of other data supplied to the Committee, reports and recommendations as to accrediting will be submitted by the Committee to the Engineers' Council, which will review the reports and act upon the recommendations.

At present E. C. P. D. is confining its program of accrediting to New England, New York, Pennsylvania, New Jersey, Delaware and Maryland. As soon as substantial progress has been made in those states and the plan of procedure under which the Committee on Engineering Schools is operating has been given a sufficiently extensive trial, authorization will be sought to extend the accrediting program to the remaining portions of the country. The Committee on Engineering Schools hopes thus to be able to inaugurate its program in the entire country during the Spring of 1936.

At the date of writing, December 16, 1935, thirty-three institutions in New England and the Middle Atlantic States have formally requested examination with a view to accrediting:

Alfred University
Brooklyn Polytechnic Institute
Brown University
Bucknell University
Carnegie Institute of Technology
Clarkson College of Technology
College of the City of New York
Columbia University
Dartmouth College (Thayer School of Civil Eng.)
Drexel Institute
Johns Hopkins University
Lafayette College
Manhattan College
Massachusetts Institute of Technology
Newark College of Engineering
New York University
Northeastern University
Norwich University
Princeton University
Rensselaer Polytechnic Institute
Rhode Island State College
Rutgers University
Stevens Institute of Technology
Swarthmore College
Tufts College Engineering School
Union College
University of Maine
University of New Hampshire
University of Pittsburgh
University of Vermont
Worcester Polytechnic Institute
Webb Institute of Naval Architecture
Yale University

The Committee on Engineering Schools comprises the following membership:

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H. P. Hammond, Polytechnic Institute of Brooklyn
A. A. Potter, Purdue University

Carroll L. Wilson, Massachusetts Institute of Technology, is Secretary to the Committee.

Charles F. Scott, Yale University, is Chairman, and George T. Seabury, American Society of Civil Engineers, is Secretary of Engineers' Council for Professional Development.

## ENGINEERING ENROLLMENTS, 1935–1936

### Distribution of Four-Year Undergraduates in Engineering by Classes, 1935–36

| Year | Number of Institutions | Total Undergraduate Enrollment | Classes | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Freshmen | | Sophomores | | Juniors | | Seniors | |
| | | | No. | % | No. | % | No. | % | No. | % |
| 1925–26 | 143 | 54,337 | 20,063 | 36.9 | 14,493 | 26.7 | 10,695 | 19.7 | 9,063 | 16.7 |
| 1926–27 | 148 | 59,853 | 22,765 | 38.0 | 16,123 | 27.0 | 11,562 | 19.3 | 9,403 | 15.7 |
| 1927–28 | 148 | 63,023 | 23,360 | 37.1 | 16,905 | 26.8 | 12,685 | 20.1 | 10,073 | 16.0 |
| 1930–31 | 145 | 73,386 | 25,332 | 34.5 | 19,631 | 26.7 | 16,262 | 22.7 | 12,161 | 16.6 |
| 1932–33 | 143 | 63,119 | 17,441 | 27.6 | 17,028 | 27.0 | 15,542 | 24.4 | 13,108 | 21.0 |
| 1935–36 | 124 | *58,323 | 20,128 | 34.5 | 14,821 | 25.4 | 12,031 | 20.6 | 10,436 | 17.9 |

* Does not include 5,814 (9%) evening students.
Does include 5-yr. students—363 (.62%); 322 special (.5%); 222 others (.38%).

### Summary of Enrollments in 124 Engineering Schools in 1935–36

| Eng. Course | Fr. 1st yr. | So. 2nd yr. | Jr. 3d yr. | Sr. 4th yr. | 5-year Cur. | Special Stud. | Eve. Stud. | Other | Graduate | | Total | No. of First Degrees Conferred during 1934–35 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | M.S. | Ph.D. | | |
| Aero | 469 | 417 | 401 | 317 | 12 | 4 | 57 | | 76 | 14 | 1,767 | 180 |
| Agri | 198 | 172 | 88 | 76 | — | 2 | | | 18 | | 554 | 66 |
| Arch | 196 | 191 | 145 | 194 | 32 | 14 | | | 10 | 1 | 783 | 155 |
| Caramic | 122 | 93 | 61 | 43 | | 58 | | | 18 | 16 | 411 | 31 |
| Chem | 2413 | 2659 | 2111 | 1705 | 84 | 25 | 527 | 18 | 342 | 115 | 9999 | 1292 |
| Civil | 1865 | 1929 | 1902 | 1897 | 44 | 30 | 689 | 9 | 415 | 38 | 8828 | 1591 |
| Elec | 2502 | 2703 | 2433 | 2203 | 60 | 45 | 1153 | 18 | 484 | 86 | 11687 | 2086 |
| Indus | 414 | 623 | 436 | 398 | 12 | 2 | 76 | 9 | 37 | 7 | 2014 | 323 |
| Mech | 2974 | 3303 | 2860 | 2283 | 77 | 49 | 948 | 19 | 383 | 20 | 12913 | 1967 |
| Met | 164 | 309 | 167 | 156 | 2 | 6 | 149 | 5 | 89 | 26 | 1073 | 192 |
| Mining | 388 | 402 | 382 | 287 | 2 | 10 | | 23 | 44 | 1 | 1539 | 300 |
| Unclass | 6918 | 576 | 56 | 9 | | 48 | 1042 | 18 | 9 | | 8798 | 22 |
| Others | 1505 | 1425 | 977 | 868 | 38 | 29 | 1175 | 3 | 115 | 40 | 6175 | 642 |
| Totals | 20,128 | 14,821 | 12,031 | 10,436 | 363 | 322 | 5814 | 222 | 2040 | 364 | 66,541 | 8847 |

150 institutions giving instruction in engineering were requested to furnish the above information and 124 had replied as of December 4, 1935. Of the 124 institutions replying, 106 reported 8,847 first degrees conferred in 1934–35.

F. L. Bishop.

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## GRADUATE STUDY

### REPORT OF PROGRESS

The survey on which this report is based is a continuation of studies of graduate work begun in 1931 by a committee of which Dean Kimball was chairman. The report of that committee, presented in 1932, concluded with the recommendation that consideration be given to the making of a comprehensive survey of the present status and trends in the field of graduate instruction. The present survey and report are made as the outcome of that recommendation.

Upon taking up its work in the fall of 1933, the present Committee invited the United States Office of Education to coöperate by collecting comprehensive data relating to graduate work from the engineering colleges and by preparing a factual summary of the information so obtained. The Committee, as its share of the project, was to prepare an accompanying report analyzing and interpreting the data and giving conclusions and recommendations.

The process of collecting the facts was launched in the fall of 1934, with the expectation of presenting final reports at the Convention of 1935. Unfortunately, this program could not be carried out. Emergencies arising in education throughout the country, and abnormal demands on the time of the Office of Education, have interrupted the work so seriously as to make its completion impossible at the scheduled time.

Portions of the assembled data with relation to specific aspects of graduate work have therefore been analyzed and the present report has been prepared by the Committee on that basis. The analyses have been prepared under a great deal of pressure. Nevertheless the summaries presented are substantially complete and accurate as to the particular topics discussed.

It is expected that the final reports on the survey will be published during the next academic year.

This report is divided into the following principal parts:

Resumé of the history of graduate work in engineering
Growth and present magnitude
Part-time and coöperative graduate work
Relationships to the faculty
Relationships to undergraduate work
Conclusion

In its final report the Committee will extend its interpretation of these topics and will give consideration to the additional topics of

Organization and administration of graduate work
The basic nature and objectives of graduate programs
Admission and graduation requirements and methods
The thesis. Examination methods
Foreign language requirements
Degree practices
Costs and facilities

## Historical

So far as can be learned from information supplied to the Committee the first earned degree in engineering that we should now call an advanced degree was awarded by Yale University in 1873. It is an interesting fact that this was not the master's degree, but the degree of Doctor of Philosophy, and it is worth recording in the annals of engineering education that this first engineering doctorate was conferred on Augustus Jay DuBois; Ph.B., Yale University (1869); C.E., Yale University (1870). The doctoral dissertation was "Strains in Framed Structures." This work was published by the house of Wiley in 1875. Dr. DuBois later became professor of civil engineering in the Sheffield Scientific School of Yale University, a post he occupied for many years.

The second institution to award an advanced degree for work in engineering was the School of Mines of Columbia University. This degree, also Ph.D., was conferred on Ellwyn Waller; A.B. (1867) and A.M. (1869), Harvard University; E.M. (1871) Columbia University. Dr. Waller's dissertation was on disinfection and disinfectants, as applied to mining operations.

Apparently it was not until more than twenty years later that another institution awarded an earned doctorate in engineering, Cornell University having done so in 1896.

The first master's degree in engineering appears to have been awarded by Iowa State College in 1879.

Although, therefore, some graduate work in engineering has been done for more than sixty years, only six institutions in the entire country, so far as the Committee has been able to learn, conferred any advanced degrees prior to 1890. At about the turn of the century, however, the offering of work beyond the baccalaureate began to spread rapidly. By 1920 at least 40 institutions had conferred master's degrees and 11 had conferred doctor's degrees. These figures are probably incomplete since not all colleges are able to state the year in which their first advanced degrees were conferred.

The most rapid expansion of graduate work has taken place since 1920, when the need of industry for men of more advanced scientific and technological preparation began seriously to be felt, and when the colleges, following the era of most rapid expansion in numbers and facilities, had consolidated their positions somewhat and began to push forward into the field of advanced work. Contrary to what has often been said, the effects of the depression have not been to cause an increase in graduate enrollments in engineering education as a whole, though they have probably contributed to the spread of enrollments among institutions. In the ten years from 1920 to 1930 21 additional colleges began to offer work for the master's degree, and 10 were added to the number offering work for the doctorate. In the half-decade since 1930 this rate of expansion has been maintained; 10 additional colleges have begun to offer work for the master's degree, and 7 have added programs for the doctor's degree. Nearly as many institutions have inaugurated programs of advanced work since 1920 as had done so in all the previous history of engineering education in this country.

Although approximately 40 institutions were offering graduate work by 1920, such work had not really begun to assume a position of great magnitude in engineering education; in the year 1921–22 there were but 368 students enrolled in graduate courses and but 178 advanced degrees were awarded. There were fewer candidates for master's degrees fifteen years ago than there are for doctor's degrees now.

The following table, compiled from data gathered by the United States Office of Education and by the Society, shows the growth of graduate enrollments since 1921–22:

TABLE 1

| Year | Total number of students enrolled in graduate work | Total number of advanced degrees conferred |
|---|---|---|
| 1921–22 | 368 | 178 |
| 1925–26 | 1,014 | 267 |
| 1930–31 | 2,939 | 418 |
| 1931–32 | 3,961 | 1,002 |
| 1933–34 | 2,756 | 1,197 |

It is to be noted that the figures for enrollments and graduations up to and including 1931–32 included *all* enrollments and advanced degrees in most engineering schools and colleges; they included, therefore, an unknown number of enrollments and degrees in certain non-engineering fields offered by engineering colleges, such as chemistry, metallurgy, geology, architecture, biology and public health, and (in one or two instances) business administration. The

figures for 1933–34 omit all enrollments and graduations except those strictly within the field of engineering proper. Apparently, while there has been a fairly large decrease in enrollments since the peak year of 1931–32, the decrease has not been nearly as large as the table indicates.

It may be noted also that numbers of degrees conferred is a better index of magnitude and growth than is number of enrollments, because the numbers of degrees automatically makes allowance for part-time students. It will be noted that the number of degrees conferred has increased without interruption for the past fifteen years.

Another significant index of the relative magnitude of graduate work is the fact that in 1925–26 the ratio of the number of graduate students to the number of seniors of the previous year was approximately 1 to 9, while in 1933–34 the ratio was 1 to 4.8.*

Until 1912 all graduate work in engineering appears to have been offered on the customary all-residence plan. In that year Carnegie Institute of Technology offered the first program of part-time work in evening hours. Shortly thereafter Union College began offering special part-time graduate courses for engineers employed by the General Electric Company. In 1919 Massachusetts Institute of Technology inaugurated its famous VI–A cooperative course in electrical engineering, and followed in 1920 with the establishment of its Practice School of Chemical Engineering. M. I. T. has also offered a coöperative course in Railroad Engineering and is about to embark upon a similar program in mechanical engineering. Wisconsin first offered extra-mural graduate work in metallurgical engineering in 1924 for graduates employed by metallurgical industries in Milwaukee, and inaugurated a similar program in electrical engineering in 1925. Polytechnic Institute of Brooklyn established the first curriculum in its present extensive evening program of graduate work in 1925. University of Pittsburgh and the Westinghouse Electric and Manufacturing Company inaugurated their coöperative arrangement of graduate work in 1927. During the past five years several other institutions have established various types of part-time programs of graduate work, as will be mentioned more fully in a later section of this report.

The last twenty years, and particularly the last decade, have been marked not only by rapid growth in enrollments but also by expansion of graduate programs into special fields and types of work, the diversity being even greater than it is in undergraduate work. A significant aspect of this development has been the offer-

* The ratio of master's degrees to bachelor's degrees conferred in 1933–34 was approximately 1 to 9.

ing of opportunities for advanced study to employed graduates, thus providing, in certain localities at least, programs so that the young engineer can continue his formal education during the period of his professional apprenticeship.

## Present Status and Magnitude

*Institutions Offering Graduate Work.*—At the present time 86 out of a total of 155 institutions in the country that offer work in engineering leading to baccalaureate degrees provide programs of graduate work. While the number is not greatly different from that in 1925, when 81 institutions offered such programs, the spread of enrollments among institutions has increased very materially during the past ten years. Furthermore, in 1925 graduate work in engineering was limited almost exclusively to programs leading to the master's degree. Enrollments were concentrated very largely in but ten institutions. While there is still a considerable concentration of students in a small proportion of the institutions (ten per cent of the institutions have two-thirds of all the students), the spread of enrollments is increasing rapidly.

Work for the doctorate is more limited in scope and in spread among the colleges than is work for the master's degree. Nevertheless, 30 institutions offered such work in 1933–34, and 27 had doctoral candidates enrolled. Four institutions alone, however, conferred over half of all doctorates in engineering in that year.

*Enrollments and Degrees Conferred.*—Table 2, page —, gives a summary of enrollments and of advanced degrees conferred in 1933–34. Attention may be directed to certain aspects of these figures:

(1) The total number of master's candidates was 2,306, as compared with 443 for the doctorate. While there has been a decrease in number of candidates for the master's degree since 1931–32, the number of candidates for the doctor's degree has continued to increase.

(2) Contrary to what might have been expected fewer fields of work are offered for advanced degrees, at least by catalogue designation, than there are for first degrees (38 compared with 79).*

(3 The distribution of enrollments, by fields of work, for the master's degree differs appreciably from that for the bachelor's degree. This is indicated by Table 3 which gives the ratio of the numbers of candidates for the master's degrees to the numbers of seniors of the same curricula during the preceding year.

* While 38 fields of work are offered for the master's degree, there are enrollments in but 24 of them.

## TABLE 2

### Enrollments and Graduations in Graduate Work, 1933–34

| Enrollments in Work for the Master's Degree | Chem. Eng. Group | | | Civil Eng. Group | | | | | Elec. Eng. | Mech. E Group | | Mining & Met. Eng. Group | | | | Aero. Eng. | Mechanics Group | | Indus. Eng. | Agri. Eng. | General Eng. | Eng. Physics | Unclassified | Naval Archi're | Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Chem. Eng. | Ceramic Eng. | Petro. Ref'g | Civil Eng. | Arch. Eng. | Mun. & San. Eng. | Railway Eng. | Irrig'n Eng. | | Mech. Eng. | Fuel Eng. | Mining Eng. | Geol. Eng. | Petro. Prod. Eng. | Met. Eng. | | Theo. & App. M. | Mech. & Hyd. | | | | | | | |
| Full-time Students | 205 | 15 | | 240 | 5 | 3 | 3 | 2 | 345 | 260 | | 33 | 10 | 8 | 72 | 84 | 1 | 12 | 27 | 8 | 5 | 5 | | 13 | 1,357 |
| Part-time Fellows, etc. | 83 | 2 | | 87 | 6 | | | | 124 | 115 | | 3 | 2 | 4 | 26 | 14 | 6 | 6 | 8 | 7 | 3 | | | | 496 |
| Co-operative Students | | | | | | | | | 85 | 8 | 6 | | | | | | | | | | | | 1 | | 100 |
| Evening Students | 22 | | 6 | 88 | | | | | 128 | 50 | | | | | 27 | | | | | | | | 28 | | 349 |
| Others | | | | 1 | | | | | 1 | 1 | | | | | 1 | | | | | | | | | | 4 |
| Totals | 310 | 18 | 6 | 416 | 11 | 3 | 3 | 2 | | 434 | 6 | 36 | 12 | 12 | 126 | | 7 | 18 | | | | | | | |
| | 334 | | | 435 | | | | | 683 | 440 | | 186 | | | | 98 | 25 | | 35 | 15 | 8 | 5 | 29 | 13 | 2,306 |
| Master's Degrees | 175 | 9 | | 193 | 1 | 1 | 2 | 1 | | 244 | 6 | 7 | | 5 | 40 | | 4 | 5 | | | | | | | |
| Conferred | 184 | | | 198 | | | | | 301 | 250 | | 52 | | | | 16 | 9 | | 19 | 23 | 3 | | 16 | | 1,071 |

TABLE 2—*Continued*

| Enrollments for the Doctor's Degree | Chem. Eng. Group | | | | | | | Min. & Met. Group | | Mechanics Group | | | | | | | Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Chem. Eng. | Ceramic Eng. | Petro. Ref'g | Electro-Chem. | | Civil Eng. | Elec. Eng. | Mech. Eng. | Min. Eng. | Met. Eng. | Theo. & App. M. | Mech. & Hyd. | Indus. Eng. | General Eng. | Gas Eng. | Aeronautical Eng. | Unclassified. | |
| Full-time Students | 94 | 8 | | 1 | | 70 | 81 | 31 | 5 | 37 | 1 | 3 | 5 | 1 | 1 | | | 338 |
| Part-time Fellows, etc. | 15 | 1 | 1 | | | 9 | 24 | 17 | 5 | 14 | 1 | 2 | | | | | | 89 |
| Co-operative Students | | | | | | | 6 | 3 | | | | | | | | | | 9 |
| Others | 1 | | | | | 2 | 1 | 3 | | | | | | | | | | 7 |
| Totals | 110 | 9 | 1 | 1 | | | | | | | 2 | 5 | | | | | | |
| | 121 | | | | | 81 | 112 | 54 | 10 | 51 | 7 | | 5 | 1 | 1 | | | 443 |
| Doctor's Degrees Conferred | 46 | 4 | 1 | 1 | | | | | | | 2 | 5 | | | | | | |
| | 52 | | | | | 8 | 21 | 20 | 1 | 12 | 7 | | | | | 2 | 3 | 126 |

TABLE 3

RATIO OF NUMBER OF CANDIDATES FOR MASTER'S DEGREES IN 1933–34 TO NUMBERS OF SENIORS OF THE PRECEDING YEAR

| | |
|---|---|
| Metallurgical Engineering | 1: 2.05 |
| Aeronautical Engineering | 1: 3.9 |
| Electrical Engineering | 1: 4.4 |
| Chemical Engineering | 1: 5.4 |
| Civil Engineering | 1: 6.2 |
| Mining Engineering | 1: 6.3 |
| Mechanical Engineering | 1: 6.6 |
| Average, All Curricula | 1: 5.75 |

(4) The distribution of enrollments for the doctor's degree differs from that for the bachelor's degree even more strikingly than does that of enrollments for masters' degrees. It will be noted from Table 2 that chemical engineering occupies a position of much greater relative importance in this field, and that it is far in the lead in number of doctor's degrees conferred; more doctorates were conferred in chemical engineering in 1933–34 than there were in any other two fields combined. A majority of these degrees were conferred by two institutions alone—Michigan and Columbia. If the doctorates in chemical engineering conferred by these two institutions were to be deducted from the total of all engineering doctorates, the picture as to the magnitude of the higher phases of advanced work in engineering would be quite different from what it is.

(5) It is interesting, and of some significance, to note the relationship of part-time enrollments of various kinds to full-time enrollments, the number of part-time students being about three-eights the number of all graduate students, and the proportion of coöperative and evening students being about one-sixth of the total. These ratios are not nearly as large as they were five years ago because of a marked decrease in enrollments in some of the special types of graduate work conducted coöperatively by colleges and industries.

*Comparison with Other Divisions of Science.*—No means are available for determining the relative position of work for the master's degree in engineering with similar work in other fields of science. The relative standing of work for the doctorate may be judged, however, by comparison of the number of degrees conferred in various branches of science. Until 1928 fewer than ten doctorates were conferred in engineering per year; it was far down the list of the sciences in this regard. By 1930 engineering had risen to eighth place. In 1933 it stood seventh; and in 1934, if the figures gathered by this Committee (which are more complete) be substituted for those of the Association of Research Libraries, which has taken over the compilations formerly made

by the National Research Council, engineering is in second place with 126 degrees, being exceeded only by chemistry, which is far in the lead of all other branches of science with 590 degrees. Physics is third in the list, following engineering with 121.

*General Characterization.*—If the situation as to graduate work in engineering can be characterized in a sentence, it may be said that work for the master's degree has become the regular order of things in more than half of our institutions and for an important fraction of our students, while work for the doctorate is beginning to assume a place of significant importance. The Committee ventures to express the opinion that it would be just as well if work for the doctorate were not to expand too quickly or spread too widely. Expansion of work for the master's degree has been extremely rapid, and it has occurred at a time when many institutions are struggling under seriously adverse conditions. It may be well for engineering education to consolidate this gain and to strengthen its position in graduate work before making any wholesale expansion into the still more advanced field of work for the doctorate.

## Subsidized Post-Graduate Work: Scholarships, Fellowships, etc.

In a supplement to this report (Appendix A) data are given relating to the number and types of subsidized opportunities for graduate work that are open to engineering students. The figures are largely self-explanatory, but one or two comments may be made concerning them.

It is interesting to note that there was a gain in total funds provided throughout the country for this purpose from 1932–33 to 1933–34, though most of this increase was in a single institution—M. I. T.

It is also significant that as many as 249 teaching fellowships and assistantships are available, an average of 6 per institution reporting them. Many of these graduate fellows and scholars are assigned to work as laboratory supervisors, but a rather large proportion are assigned to regular classroom instruction. The practice of using graduate students as classroom teachers has been followed to a greater or less extent for a long while, but it has grown rapidly as a result of curtailed budgets and expansion of programs in the past five years. The Committee calls attention to this situation as one deserving most careful consideration.*

* For further discussion of subsidized graduate work see remarks by Edward Bennett, page 538, Journal of Engineering Education, for April, 1935.

## Coöperative and Part-Time Graduate Work

One of the most significant phases of the development of graduate work, already referred to briefly in preceding paragraphs, has been that of the provision of part-time courses of various types, many of them being for the benefit of graduates who have found regular employment but wish to continue their education through regular academic work.

The ways in which institutions have capitalized the particular advantages of their environment and facilities in this connection provide an interesting study.

*Carnegie Institute of Technology* appears to have been the first to offer graduate work on a part-time basis, having established such courses in 1912. The first degree was conferred in 1915. The courses are regular graduate engineering courses offered in evening hours. Enrollments in 1933–34 were 52. Twenty-two degrees have been conferred under this plan since 1915.

*Massachusetts Institute of Technology* inaugurated its coöperative course in electrical engineering in 1919. This program is an integrated five-year course having the first two years on the all-residence basis and the last three years coöperative, with alternation of periods at the Institute and in industry on a semester basis (including a summer term). One full year of graduate work is provided. The course leads to two degrees, the bachelor's and the master's. The curriculum provides a comprehensive foundation for engineering, including the scientific, economic and sociological aspects. Four options are provided as special fields of work, and coöperative employment is provided in each of them with selected industries as follows:

Electrical Manufacturing—practice with the General Electric Company
Electrical Communications—practice with the Bell Telephone System
Electrical Power Generation and Distribution—practice with the Edison Electric Illuminating Company of Boston
Electrical Transportation—practice with the Boston Elevated Railway.

Admission to the course is on a selective basis and places a premium on high scholarship and good personal qualities, a practice that has been done much to insure its success. Classes are continued under resident and non-resident Institute instructors while the students are at the plants of the companies on their coöperative work. Many of the students are selected to study under the Honors Group Plan during the Junior and Senior Years, which pro-

vides unusual opportunities for the development of initiative and resourcefulness by placing the students more largely on their own responsibility.

The total enrollment in the course to date has been 601, the maximum enrollment in any one year having been 127, in 1924. The enrollment this past year has been 69, a substantial decrease having occurred since 1930 due to industrial conditions. Three hundred seventy master's degrees have been conferred.

M. I. T. also offers a coöperative post-graduate course in its School of Chemical Engineering Practice, which is essentially a fifth year of work following the normal four-year undergraduate curriculum. Twenty-four weeks of the year are spent at three practice school stations in industrial plants. These are followed by 15 weeks of graduate study and thesis work at the Institute. Admission is selective and is limited to students of high professional promise. More than half of the students come from institutions other than M. I. T. Members of the Institute instructing staff are in charge of the practice stations. Students are assigned regular plant problems, many of which are of direct interest to the plant organization. The practice schools are supplemented by a shorter course for seniors, thereby permitting twelve-month operation.

The course was established in 1920. The total enrollment has been 757 since its establishment. Twenty-three students were enrolled in 1933–34. Three hundred fifty three master's degrees have been conferred.

From 1928 to 1934 M. I. T. offered a coöperative course in Railroad Operation through an arrangement with the Boston and Maine Railroad.

From 1925 to 1933 a program of graduate study was also provided by the Institute for the younger engineers of the Lynn works of the General Electric Company. The instruction consisted of graduate subjects in electric circuits and advanced alternating-current machinery, given by Institute instructors over a period of 16 months at the Lynn works. During the same period the students were attending a seminar and starting work on their theses. The requirements for the master's degree were completed by a term of residence at the Institute. The course was discontinued in 1933 due to the fact that relatively few younger engineers were being taken on by the Company. During its existence 84 students were registered in electrical engineering and 39 master's degrees were granted; approximately 38 students were registered in mechanical engineering, and 15 degrees were granted.

A further step in the program of coöperative post-graduate work in engineering is to be taken at the Institute next year in the

form of a new course in mechanical engineering, called II–A, which is to be similar to the existing coöperative course in electrical engineering, VI–A. The course is being established at the request of the General Electric Company.

*Polytechnic Institute of Brooklyn* began offering graduate work in its Evening Session in 1925, in chemistry, and in 1929 expanded its program to include all of its engineering curricula as well. The work has met with a widespread response among younger employed engineering graduates in the metropolitan district of New York. The customary types of graduate courses as well as original work and research, carried out through theses, are provided, the thesis work being of very high quality. An average of from 3 to 4 years is required to complete the work for the master's degree. The total enrollment has been 1423 since the inception of the plan ten years ago, and 127 degrees have been conferred. The total enrollment in 1934–35 was 295, 153 being in engineering and 142 in chemistry.

*The University of Pittsburgh and the Westinghouse Electric and Manufacturing Company* inaugurated their coöperative arrangement of part-time graduate work in 1927. Under this plan instruction is provided jointly by the University and the Company for young engineers employed by the Company. Classes are conducted on the premises of both under teachers designated by the University from among its own faculty and from among the older engineers and research workers of the Company's staff. The entire work of the students is done under the broad guidance of the University's School of Engineering, and the University assumes responsibility for the adequacy of the program. Most of the engineering subjects are given by teachers chosen from the Company's staff, while courses in physics, mathematics, economics, and the like are given chiefly by members of the University's faculty. Experimental work on theses is conducted in the Company's laboratories, but no credit is given for any shop, testing, drafting, or regular engineering work done by the student during working hours. Theses are of a high order of excellence.

The courses lead, upon completion, to the master's or to the doctor's degree. Enrollments have run as high as 250 men in a single year (1930), though there has been a considerable shrinkage since 1931 due to the depression. This year 33 men are enrolled. A total of 61 master's and doctor's degrees have been awarded.

*University of Wisconsin* provides an example of another distinctive departure from the customary all-residence type of graduate program, and one of a high order of usefulness and of quality of work, in that conducted for younger metallurgical engineers employed in industries in Milwaukee. This work was inaugurated

in 1924. The program makes it possible for a limited number of properly qualified technical graduates employed by metallurgical industries to advance their knowledge and to develop their research ability under instruction and leadership provided by the University. Instructors make the trip to Milwaukee each Friday, hold regular classes that evening, and spend Saturday with the students at their plants going over their research problems. The students are regularly enrolled as graduate students of the University—not in its Extension Division—and upon completion of the course work and thesis are awarded the master's degree. The total enrollment in the course, to date, has been 52. Twenty-two master's degrees have been conferred. The enrollment in 1933–34 was 5.

A similar program was offered by the University in electrical engineering at the solicitation of engineers in Milwaukee during the years 1925 to 1927, inclusive. Forty men were enrolled during the existence of this course.

Other institutions that have offered special types of graduate work, chiefly for young employed engineers, include:

Union College, which offered graduate courses for engineering graduates employed by the General Electric Company for a period of about 15 years. The master's degree was awarded upon completion of a two-year program and the submission of a satisfactory thesis. The arrangement was discontinued in 1932 when the college temporarily gave up all graduate work due to the effects of the depression. Possibility of resumption of the program is now being considered.

Case School of Applied Science, which offered graduate work in evening hours, has also discontinued this type of program temporarily.

In addition to the foregoing, several other institutions offer special types of programs, chiefly in evening sessions. Among these are the courses that have been provided by Columbia University since 1932. The work is offered in late afternoon and early evening hours. Twenty-eight men are enrolled in this work during the present year, many of whom are employed in such organizations as the Bell Telephone Laboratories. New York University inaugurated a program in 1933 in its Evening Engineering Division whereby the degree of Master of Science in the field of hydraulic and sanitary engineering may be earned in two years. An average of 10 students have been enrolled annually. The University of Pennsylvania also offers work in evening hours both in the Moore School, where 40 students are enrolled, and in the Towne School where there are 25 enrollments. The University of Minnesota has recently launched a program of evening graduate work and has 22 men enrolled in the electrical engineering courses this

year. In addition to the foregoing, the University of Cincinnati, Detroit Institute of Technology, Louisiana State University, the Montana School of Mines, and Virginia Polytechnic Institute offer special types of coöperative courses in which a total of 16 students are enrolled.

In all, 15 institutions now offer various special types of post-graduate work, the total enrollment of engineering students in such programs during the year 1933–34 having been 330. This is a sizable fraction of the entire enrollment of graduate students and the types of work provided form one of the most significant developments in graduate work in engineering.

## Graduate Work and the Teaching Staff

Probably in no other respect has the advent of graduate work in engineering had more important effects than in relation to the teaching staff. Information furnished by the survey bearing upon this matter will be considered from two standpoints: (1) Problems of administration, and (2) recruitment and training of younger teachers and the elevation of standards of instruction.

*Adjustment of Teaching Loads.*—Practice in this connection, as revealed by the survey, differs considerably. In many institutions the load of graduate instruction has been added to the previously existing load of undergraduate instruction, which, as pointed out in the Report of the Committee on Teaching Personnel (Bulletin No. 4 of the Investigation of Engineering Education), was already heavy in comparison with other divisions of higher education. The cause of this, of course, has been the necessity, in many institutions, of adding graduate work to the undergraduate programs already offered without making any additions to the teaching staffs. In one or two institutions relief of this situation is planned, but has not been carried into effect due to financial limitations. In most institutions where additional staff has been provided to take care of the increased load, hours of graduate and of undergraduate instruction have been given equal weight, though there are one or two important exceptions to this practice. Commenting in this connection, several correspondents mention that graduate instruction is carried for the most part by the senior members of the staff whose previously lighter schedules could be increased most readily. One correspondent remarks that the older teachers whose schedules were lighter than average so as to give opportunity for study, writing and research, have now taken on graduate work. Several institutions report that teachers assigned to graduate work have been relieved of a corresponding amount of undergraduate work, though in most institutions there has been no such relief.

Little or no attempt is made, apparently, to weight graduate work in relation to undergraduate work in arriving at a measure of teaching loads. In a few schools that report such effort, one unit of graduate work is taken as the equivalent of one and one-half units of undergraduate work. One institution uses a ratio of 1 to 2 in this connection. Graduate thesis supervision is systematically weighted in only a few institutions: one counts supervision of one thesis as 5 per cent of a full teaching schedule; another counts supervision of one master's thesis as the equivalent of one unit of lecture or recitation work, and supervision of one doctor's thesis as the equivalent of 2 hours of lecture or recitation work.

It may be said in summarizing the matter of teaching loads that the advent of graduate work at a time when budgets were being curtailed, and when some staffs were being decreased in numbers, has prevented the normal adjustment to the increased duties that otherwise could have taken place. Graduate work has unquestionably come to stay in engineering education. It is entirely probable that it will increase in scope. If, as was the case in 1934–35, undergraduate enrollments are again to increase as they did prior to 1932, increases in teaching staffs will be imperatively necessary. This problem, in view of possible continued restriction of operating funds, promises to be a serious one.

*Extra Compensation.*—In general no extra compensation is allowed for graduate instruction except when the work is conducted in evening sessions. In such cases compensation is commonly made on an hourly basis. In one case 50 per cent greater hourly compensation is allowed for such work than for undergraduate work.

*Visiting and Exchange Professors.*—Eight institutions report that they have had experience in this connection, and three others state that they have plans for exchange of professors in the near future. At least two institutions, M. I. T. and Michigan, have arranged for visiting professors during the coming summer sessions, the arrangement at Michigan being in connection with advanced courses in mechanics particularly well adapted to university teachers. It must be remembered that when exchange is between two institutions in this country the same exchange is reported twice in response to the committee's inquiry. The practice of exchange of teachers is not, therefore, one that has found very wide adoption. The committee believes that it might well be given a much more general trial than has been the case thus far.

*Recruitment of Teachers.*—It is evident from statements of fact and of policy submitted to the committee that a marked change of attitude is taking place toward the extent and nature of training demanded of candidates for teaching positions. Approximately five-eights of all institutions reporting state that they either

require the holding of the master's degree as a minimum or that they give great weight to it in choosing new men. (The holding of an advanced degree is an absolute requirement in 23 of 81 institutions reporting; 8 others virtually make the same requirement without having a fixed rule, and 5 others make it as a definite requirement for advancement to posts beyond that of instructor. One additional institution is to lay down a rule as to the holding of advanced degrees during the coming year.) Replies indicate that the weight given to the holding of advanced degrees is just about equal to that given to practical experience—the latter being, of course, in relation to instructorships in engineering subjects. Only a small minority of institutions report that little or no weight is given to possession of advanced degrees.

In a few institutions the attempt is made to require all those appointed to full professorships to hold the doctor's degree. The Committee is not informed specifically as to how completely this rule is enforced as to members of the engineering faculty.

Nearly half of all institutions reporting state that they have changed their attitude and policy in recent years in the matter of requiring newly appointed teachers to hold advanced degrees, the change having been in the direction of much greater emphasis on advanced training. The present situation is quite different from that of the days when practical experience was the sole requisite for appointment—except, of course, the holding of the bachelor's degree—and when possession of an advanced degree was so uncommon as not to be a factor.

If the Committee is correct in its inference, the change that has taken place is due more to the fact that candidates having advanced degrees are now available than it is to the desire to lay down definite prescriptions. Whatever the cause, however, possession of an advanced degree has become so much an asset among applicants that a recent graduate applying for a teaching post who does not hold such a degree can scarcely expect to receive consideration in a majority of institutions; the most he can look for is some form of fellowship under which he can pursue graduate work before he can rise to a full instructorship.

*Self-Advancement of Teachers.*—It is the policy of nearly all institutions to encourage and systematically to aid their younger teachers to continue their academic training. Nearly three-quarters of the institutions report that they have definite plans in this connection. Comparatively few of them go so far, however, as to have systematic provisions for sabbatical leaves.

Evidence points unmistakably to the fact that teachers are availing themselves of opportunities for advanced study and that they are fully awake to the fact that more extended academic

training is becoming essential to promotion. Among the staffs of 68 colleges reporting, 443 teachers are now pursuing graduate courses, an average of over 6 teachers per institution, or about 15 per cent of the entire staffs of those institutions. Among the teachers of 69 institutions which supplied information, 655 teachers, or nearly 10 per institution, and about 17 per cent of the entire faculties, earned advanced degrees during the past 6 years; a truly remarkable record, particularly in view of the fact that several of the larger institutions are not included because they could not assemble the information.

The chief means by which teachers have earned degrees is through the opportunities afforded by their own institutions, though a significantly large fraction of the work has been pursued in summer sessions of other institutions. During the summer of 1934 fifteen institutions provided such work, the total number of engineering students enrolled being 422, of whom 123 were teachers. Nearly two-thirds of this enrollment was in two institutions: M. I. T. and Michigan.

Some of the most interesting developments in post-graduate work have had important connections with these summer sessions: the work in hydraulics under Woodward, Mavis and the late Professor Nagler, at Iowa; photo-elasticity under Frocht at Carnegie Tech.; theoretical and applied mechanics under Erickson, Timoshenko and others at Michigan being conspicuous illustrations of the development of distinctive programs around teachers of particular qualifications.

The Committee would remark in this connection that it is in just such ways as these that graduate work is probably destined to have its most beneficial effects on engineering education in this country; that is, by tending to aid in the development of centers of particular types of advanced work of high quality and of distinctive characteristics. It is only in the cases of a minority of the engineering schools of the country that staffs, facilities and resources are such as to provide for comprehensive programs of graduate work of high quality in all fields in which undergraduate curricula are offered, but many institutions can capitalize particular assets in the way of staff, facilities and location and provide distinctive programs in special fields.

*Conferring of Advanced Degrees on Members of the Institution's Own Staff.*—The taking of advanced work in the teacher's own institution has intensified a situation that has been something of a problem in many institutions; namely, that of the policy as to conferring degrees upon members of the institution's own staff. Two views as to this matter are commonly expressed: (1) that there should be no discrimination against the institution's own teachers,

and that the school should be free to profit by the advanced training of its own men; and (2) that restrictions are needed to guard against the danger of questionable practices in degree-conferring.

The prevalence of various practices in this connection is shown by the following tabulation:

TABLE 4

| | |
|---|---|
| No limitations | 22 institutions |
| Advanced degrees limited to assistants and instructors | 38 institutions |
| Advanced degrees limited to assistants, instructors, and assistant professors | 12 institutions |
| All except full professors eligible | 1 institution |
| None conferred on any member of staff | 2 institutions |
| No answer, or no definite policy | 6 institutions |

Several interesting variants on the usual regulations are reported. One institution provides that all teachers of any rank higher than that of instructor must receive special permission from the dean of the graduate school to enroll for an advanced degree. Another permits instructors to earn degrees in any field, but will not permit an assistant professor to take work in his own department. Another will not permit its own teachers to take work for the master's degree, but will permit them to work for the doctorate. Still another will not confer any degrees on members of the faculty of the graduate school, but imposes no limitations on other teachers.

## Relationship of Graduate Work to Undergraduate Work

It is inconceivable that the rapid development of graduate work, with its attendant effects on teaching staffs, on institutional policies, and on other aspects of engineering education, as pictured in some measure in preceding paragraphs, could have taken place without having important effects on undergraduate work.

Before discussing this matter it should be noted that simultaneously with the rapid growth of graduate work, and even preceding it by a few years, a perceptible change was taking place, quite independently, in the nature of undergraduate work: requirements for the bachelor's degree were being decreased; curricula were being simplified; emphasis was shifting from the more advanced technical courses and from purely descriptive work to the more deeply fundamental subjects; less time was devoted to the more mechanical types of work, and the time so released was devoted, in considerable measure, to humanistic studies.

As a part of its project the Committee believed that it should make some attempt to appraise, at least in a general way, the influence of graduate work on undergraduate work, both in relation

to the movement just mentioned and to effects that may have occurred independently of that movement. In doing so the Committee has not lost sight of the fact that the foundation of engineering education is and should be its undergraduate program. Without a sound basis of fundamental training provided by the undergraduate curriculum, any program of advanced work will be without real merit. Improvement of graduate work, in the long run, can not proceed farther or faster than the strengthening of undergraduate work permits. The great concern of engineering education, therefore, is to insure the maintenance of sound and adequate undergraduate programs as the foundation on which the development of graduate work must rest. This is not to say that the development of graduate work may not aid materially in enhancing the standards of undergraduate work, but it does mean that in our efforts to add to our programs of work at the top we must not neglect our foundations.

As a means of obtaining some light on the general effects of graduate work on undergraduate work the Committee submitted the following questions to its correspondents:

(1) Has there been any perceptible tendency, as work for advanced degrees in engineering has been developing during the past two decades, to transfer from the undergraduate curriculum any of the more advanced engineering courses to the graduate program?

(2) Has the development of graduate work in the past two decades had any other perceptible influence upon the content, purpose, scope or other characteristics of undergraduate curricula?

It is unfortunate, perhaps, that the Committee did not ask whether the reverse of the tendency mentioned in the first question had been observed. However, information on that point was given voluntarily in a number of replies.

In answer to the question as to the transfer of work from undergraduate curricula to the graduate field 48 of 79 correspondents replying stated that no such tendency had been observed. Eighteen institutions reported that there had been such a tendency, and 10 volunteered the information that the tendency had been the reverse; namely, the transfer of subject matter from graduate to undergraduate curricula. Apparently there has been a good deal of difference in the trends in different institutions. Strangely enough, two schools of engineering in the same university report opposite tendencies. The whole matter is of so much interest and importance that a few replies may be quoted as indices of the general trend.

In relation to the transfer of work from undergraduate to graduate curricula one correspondent writes—"Yes, the tendency has been to stress fundamentals and humanistics in undergraduate

work and to offer the more specialized topics in graduate courses." Another says—"Yes, due to increase in requirements in fundamental sciences, economics and electives." These two replies are typical of several explicit statements indicating that the effects of the introduction of graduate work has been to cause greater stress to be laid on fundamentals and to cause the transfer of certain of the more advanced specialized engineering courses to the graduate field.

Another group of replies may be illustrated by the following typical answers: "No, but many new courses have been developed (in the graduate field)." Several others state that the contrary trend has prevailed and that certain subjects, formerly considered as of graduate status, are now offered in the later years of the undergraduate program.

Replies indicate very clearly that graduate work demands a more fundamental and sounder preparation in the basic elements of engineering science. The program of graduate work appears, therefore, to have become something of a measuring stick by which the adequacy and effectiveness of undergraduate work may be evaluated.

The replies also indicate that the influence of graduate work is to direct undergraduate engineering education, by and large, into the more scientific phases of the design and research functions of engineering, and less into the operation, administration and sales functions. There can be no dissent from the aim of placing engineering education on the highest possible plane of quality and effectiveness; and it is probably correct to say that the influence of graduate work has been in that direction. But to assume that its influence still further to direct engineering education toward the more strictly technical aspects of the profession and to develop it still further on the side of physical science at the sacrifice of emphasis on the administrative phases is a matter that may well be given serious consideration.

As to other influences of graduate work on undergraduate work the Committee offers the following quotations:

One correspondent writes—"The development of graduate work has naturally improved the character of undergraduate teaching." In the opinion of the Committee this is the most beneficial effect that graduate work could possibly have on the general character of engineering education. Another correspondent phrases the same general thought in the words—"It has improved undergraduate work and placed it on a higher plane." Another writes—"It has intensified the scientific character of the undergraduate program. Less emphasis is being placed on the practical." Another says—"It has reacted to increase emphasis on fundamentals

and on the scientific subjects of undergraduate curricula. The tendency of undergraduate courses to be planned for the more highly specialized graduate courses has been emphasized." Another writes—"There has been more emphasis on the scientific basis of design and less on mere drawing and routine computations." Another notes—"Informational courses have been abandoned." This, also, in the opinion of the Committee is a change for the better.

A trend differing from those above quoted is noted by one who writes—"Graduate work has helped to keep undergraduate work from becoming too technical, with too little humanities, etc. It has tended to make undergraduate work more general."

As to changes in methods of instruction, replies indicate several interesting changes in undergraduate work. One states—"More use is now being made of the conference and research methods of instruction. It, (*graduate work*) has been a great stimulus to scholarship. Small research projects have been introduced for seniors." Another says—"Time in class has been reduced and more out-of-class work has been required." Another summarizes the situation by remarking—"It has raised the level of original and independent work through the institution."

As a concluding quotation, the following may be cited as indicative of the general leavening effect of graduate work through engineering education at large: "The effect of graduate work has been revolutionary, stimulating the faculty and the interest of the students in their work."

As a final effect of graduate work the Committee believes that it has tended to fix four years as the normal length of the undergraduate program. No positive evidence of this influence can be adduced from the replies to its inquiries, but the Committee believes that the lengthening of the general program of engineering education through the widespread provision of a fifth year of work for the master's degree is tending to effect the lengthening of the normal period of engineering education that has been so often and so strongly advocated. That any considerable number of institutions will provide both the longer undergraduate curriculum and added years of graduate work for advanced degrees does not seem probable.

## Conclusion

The Committee concludes its report of progress at this point simply because limitations of time and energy have not permitted it to go farther. Enough has been said, even though in preliminary fashion, to indicate that graduate work has, with surprising

rapidity, assumed a position of major importance in engineering education. It is no transient phenomenon of depression years; graduate work has become a perfectly normal part of the programs of a majority of our colleges and of a significantly large proportion of our students. Engineering education has been taking this great step in its development largely during a period of great stress throughout education and the country at large. Any division of work that has grown so rapidly during a period of acute financial limitations must inevitably have brought with it problems that will require most careful attention to solve properly. Can many of the schools already operating under abnormal conditions, in comparison with pre-depression days, continue to provide sound undergraduate programs, possibly for increasing numbers of undergraduates, and at the same time expand rapidly into the field of graduate work? What should be the relationship of graduate to undergraduate work and how shall the aims, purposes, content and methods of the two be correlated? How shall added burdens on institutional facilities, and particularly on the faculty, be met? Can institutions in the same general vicinity coöperate in their graduate work, thus strengthening the general situation and avoiding needless duplication of effort? These and numerous other problems are before us for consideration.

The Committee expects to complete the project it has undertaken and to present its final report thereon during the coming year. It may be repeated, at this point, that its final report, which will be concerned more with questions of policy than with matters of statistical fact, will be more largely analytical and interpretive than its present report. It hopes that the completed undertaking will be serviceable in the consideration of the problems just mentioned and those others that will arise inevitably in the development of graduate work in engineering education.

Respectfully submitted,

THE COMMITTEE ON GRADUATE STUDY,

T. R. AGG,
EDWARD BENNETT,
DEXTER S. KIMBALL,
PARKE R. KOLBE,
THORNDIKE SAVILLE,
GEORGE B. THOMAS,
CARLTON E. TUCKER,
H. P. HAMMOND, *Chairman.*

June 26, 1935.

## APPENDIX A

### Scholarships, Fellowships, Etc.

*Fellowships and Scholarships making no demands on the student's time:*

Total number available, 426.

Stipends range from remission of tuition to as much as $1,500 per year. Most of the stipends are less than $500 per year. Many are from $200 to $300 per year.

*Fellowships and Assistantships requiring part-time service in research or testing:*

Total number available, 124.

Stipends range from a small sum, such as $100 per year, plus remission of tuition and fees, to as much as $1,000 per year, without remission of tuition and fees. The modal tendency is toward $400 to $600 per year.

Time required in research or testing ranges from 6 to 8 hours per week to full-time. Half-time to the institution and half-time for study is a common arrangement.

*Teaching or Laboratory Assistantships requiring part-time service in instruction:*

Total number available, 249.

Stipends range from remission of tuition and fees to as much as $1,200 per year, $400 to $600 per year being a common stipend.

Services to the institution range from 4 or 5 hours per week to half-time. The latter is a common arrangement.

*Industrial Fellowships:*

Total number available, 50, in 25 institutions.

Stipends range from $400 to $1,800 per year, several being within the limits of $500 to $1,000 per year.

Half-time service is usually required. Fellowships paying the largest stipends—$1,500 to $1,800 per year require full-time services on research.

*Miscellaneous:*

In addition to the foregoing, 18 positions of miscellaneous types are open to graduate students. The compensation ranges from 35 cents per hour for occasional work to $540 per year for half-time duties. Work ranges from night librarian to power plant operations.

A few institutions also permit graduates who are unemployed and cannot afford to pay the fees to attend graduate classes without charge.

Total funds available as stipends for scholarships and fellowships open to advanced students of engineering were $261,854 in 1932–33 and $293,078 in 1933–34, a gain of 12 per cent. Most of this gain occurred in one institution (M. I. T.). A majority (34) of those reporting a change in connection with fellowships and scholarships stated that there had been a reduction in number available, or in stipends, or in both. A few institutions (10) reported gains in these particulars.

In certain instances the numbers of scholarships and fellowships reported above are open to graduate students of the institution at large. Most of the positions, however, are open to engineering students only.

## ENROLLMENT AND DEGREES

By W. C. JOHN

Senior Specialist in Higher Education, U. S. Office of Education

In dealing with dry enrollment figures I hope I can make them interesting by pointing out the relation of engineering enrollments and degrees on the graduate level to total enrollments and degrees on the same level in this country.

According to the latest estimates based on the figures of the Office of Education for 1931–32, the total number of male graduate students should approximate about 55,000 for the year 1933–34. Against these figures we have for that year 2,756 graduate students in engineering or 5 per cent of the total indicated.

As to advanced engineering degrees, not including professional engineering degrees, 178 were reported in 1921–22. In the same year, according to the Biennial Survey of Education, graduate degrees were conferred on 5,445 men and 1,882 women, a total of 7,327.

In 1927–28 a special study was made of the masters degree by the Office of Education. This showed that 11,778 masters degrees of all kinds were granted in that year. Of these 370 were masters degrees in engineering.

In 1932–33, 19,339 masters degrees of all types were conferred of which 1,026 were in engineering.

In 1933–34, 1,197 advanced degrees in engineering were granted as against the estimate of a total of 25,000 advanced degrees including all fields.

On the basis of the figures for 1927–28, about 76 per cent of all masters degrees are masters of arts or masters of science largely in the fields of pure arts and science. A few masters degrees in this group may be in engineering or education. The next in number are the masters degrees in education with 7 per cent, the next masters degrees in business and commerce with 4.2 per cent, and

then the masters degrees in engineering with 3.1 per cent. Today this figure does not lack much of 5 per cent, doctors degrees not being included.

In view of the great increase in the total number of advanced degrees granted since 1921–22, the increase in advanced engineering degrees granted has been remarkable.

In connection with Professor Hammond's statement that the first advanced engineering degree granted in this country was a Ph.D.—granted by Yale University in 1871, it may be also of interest to note that Yale University granted the first Ph.D ever granted in this country. This was in the year 1861. Your attention is called to this because one of our leading periodicals gave that distinction to another university, which is not correct.

## POST GRADUATE EXAMINATION METHODS

By CARLTON E. TUCKER

Associate Professor of Electrical Engineering, Massachusetts Institute of Technology

The replies to the question about post graduate examination methods on the questionnaire concerning graduate work in Engineering Education, which was circulated last fall by the U. S. Office of Education, indicate a wide variety of practice. They did not in general make clear the distinction, if any, between the practice for the master's and the doctor's degrees. Consequently the statistics herein summarized may apply to the master's degree, the doctor's degree, or both.

With reference to examinations in prescribed and other formal courses, 43 reported that the conventional written examination is required, 6 reported that the written examination may be omitted at the option of the professor in charge. Two institutions indicated that a written report may be submitted in lieu of an examination. Three institutions reported the use of a written or oral examination, one that the examination may be waived in case the term record is B or better, and 30 made no reply. Apparently it is still the common practice to utilize the usual written examination in each course taken towards an advanced degree.

The answers to the question relating to examinations for admission to candidacy for a degree indicate a wide divergence in the interpretation of the question and in the practice among institutions. Some answered considering the question with reference to admission of the student to graduate courses, as indicated by the fact that 21 institutions reported no examination, 12 reported that an undergraduate record of high standing was required, and

4 indicated that an examination might be required for admission to graduate work.

Other institutions do not consider a student a candidate until he has demonstrated his ability to do graduate work successfully as shown by the next group of answers. Two required satisfactory completion of a quarter's work for admission to candidacy for the degree. Four institutions reported both oral and written examinations required, 3 reported an oral, 2 reported a written examination, 5 reported admission to candidacy after passing the prescribed courses on the program, while 4 indicated the requirement of written examinations in modern languages and minors, and oral and written examinations in the field of the major. Three replies were scattering and 33 made no answer to this question.

Apparently a common practice is to grant the master's degree upon completion of the prescribed program of studies without any comprehensive examination, although a few institutions do require both written and oral comprehensive examinations for the master's degree. For the doctorate it is common practice to withhold approval of the thesis until oral or written examinations covering the major and minor fields as well as the language requirements are passed.

Two schools reported three years of acceptable professional practice as a requirement for admission to candidacy for a professional degree.

As to the use of comprehensive examinations, 30 reported an oral examination, 6 reported an oral examination on the thesis only, 15 reported an oral and a written examination, and eight reported a "comprehensive." Twelve reported the use of either an oral or written examination or both, one indicated that the oral examination was considered of but little value, 7 reported no comprehensive examination and 15 did not reply to the question. As the use of the word "comprehensive" was not defined it is not certain whether the examinations were comprehensive in their coverage of one subject or of a field. However, since many of the examinations covered the major, the minor and the thesis, it is fair to assume that many of them apply to a comprehensive coverage of the field.

Ten replies indicated that the length of the oral examination ranged from one to three hours with two hours the most common.

Eighteen institutions reported that the examining committee was appointed in accordance with faculty rule, 16 that it was appointed by the dean, 8 reported appointment by the head of the department, 3 reported appointment by the president, 3 appointment by the graduate committee, and 15 did not indicate the method of appointment of the examining committee.

The membership of the examining committee is indicated to be as follows: twenty-three institutions reported representatives of major and minor departments and the thesis supervisor; 7 reported each professor who had had the candidate in class; and 7 reported the major department, the thesis supervisor, and a representative of the graduate committee. Four reported the major and minor professors, the thesis supervisor, and a representative of the graduate committee who had not had the student in class; two reported the graduate committee; one the committee in charge of the student's program of studies, and 15 did not reply.

Sixteen reported the department head as chairman of the committee.

Six institutions reported that the examination was open to the public and in one of these cases it was stated that any of those present could ask questions of the candidate but only the candidate's examining committee could vote on the recommendation for the degree.

The replies indicate that the oral comprehensive examination is common in graduate work, and that the examining committee is made up of representatives of the departments involved. The practice of a few institutions in specifying at least one member of the committee who has not had the candidate in class seems a very desirable arrangement.

In conclusion it can be said (1) that the written examination is still widely used, (2) that there is a considerable variation in the practice among institutions in rating a student as a candidate for a degree and (3) that oral comprehensive examinations covering the field of graduate study are commonly used.

## RELATION OF GRADUATE WORK TO UNDERGRADUATE WORK

By W. E. WICKENDEN

President, Case School of Applied Science

Here is plain evidence that we have given up trying to argue our way through the problem of the length of the engineer's training and are working it out, engineer fashion, experimentally. We are trying to solve the problem not by imposing arbitrary legislation upon our group of colleges, but by methods which are individually and institutionally selective. This method is in full accord with the sagacious report which was presented by Dean Doherty yesterday afternoon.

Agitation for a five- or a six-year combination undergraduate curriculum in arts and engineering has subsided under the weight of the fact that eighty-six of our colleges are now offering work be-

yond that required for the bachelor's degree and that the enrollment in these advanced courses has reached a ratio to our total undergraduate body of more than one to six. Superficially, it might seem that we have chosen to deepen rather than broaden our basic program, but it is reassuring to have this Committee report that the predominant effect of the spread of post-graduate work has been to simplify and to liberalize the undergraduate course, now that we have ceased to look upon it in terms of finality.

It is reassuring to learn that this new interest in advanced work has not threatened the primacy of undergraduate work. No engineering institution to my knowledge has yet suggested, as has one of our great universities, that it tolerates an undergraduate division only as an experimental project in processes of instruction.

On the contrary, there have been positive gains to our undergraduates. The greatest of these seem as yet to be in intangibles. To be sure, the introduction of graduate courses has tended to enlarge the scope of elective work for seniors with some time freed by advanced standing. As an illustration, I may cite the mixed group which has been studying the theory of matrices in our Department of Mathematics at Case, a condition of which we scarcely could have dreamed ten years ago. However, I believe that the chief advantage to our undergraduates has come from their daily contact with a group of more mature and more self-motivated men, working semi-independently.

The addition of graduate work to our program has tended to sharpen the contrast between the teacher who is a first-hand authority and the one who serves as a conduit for knowledge already conventionalized. Graduate work tends to gravitate selectively to men and departments who are not merely alive but creatively alive. Our seniors are too smart a group to miss the significance of this fact.

In appraising the values gained on the undergraduate level, much weight belongs to the fact that we are experimenting with new processes of teaching, less disciplinary, more intimate and more largely based on self-direction under guidance, than anything we have yet dared to attempt with immature students. It has been said that actually there is no such thing as good teaching in any of our university graduate schools, that the only proper function is one of guidance and criticism. As engineers, we are too intent on a demonstrable result to content ourselves with any such idea. There is good teaching being developed in our graduate divisions, but it differs significantly from our familiar procedures. The time is not far off, I hope, when the result will appear in our undergraduate work. Personally, I look forward to the day when gain in experience and relief from financial stress will make it

possible for our faculty to consider the admission of selected men at the beginning of their senior year, to what is essentially a graduate program of two years of candidacy for the master's degree with the sort of elective curriculum and of intimate and personalized regime which we are developing experimentally with our present graduate students.

My own view is that the growth of graduate work represents the working out within our colleges of the urge so often expressed in this Society these last ten years to develop, broaden and enrich engineering education. The realignment we are thus working out between a somewhat formalized undergraduate program and a much more autonomous post-graduate program, I believe, contains the germ of our answer to the propaganda that is developing in certain quarters for setting limits on entrance to the engineering profession through an arbitrary restriction of admissions to our engineering schools. With your indulgence, therefore, I should like to include in this discussion part of an address * which I recently gave upon that subject.

"The profession of engineering is not a caste, but a vaguely bounded nucleus within a large body of technical workers. No wall separates them as a membrane divides the yolk from the white of an egg. The gradations of function are imperceptible. The professional nucleus continuously is drawing into itself much of the superior talent in the outer mass, on the one hand, and on the other continuously sending men out into almost purely executive functions. Close these free paths of interchange between professional, executive, commercial, and producing groups and, in my opinion, the engineering profession quickly will sterilize itself.

"Why not separate higher technological education into two quite distinct compartments? In one, train men for purely professional work as engineers; in the other, provide training of a more elastic character for the general service needs of industry? Whatever the abstract merits of the idea, the practical difficulties of converting the existing educational machinery to this dual function are fairly forbidding. The experience of such engineering colleges as have sought to become professional schools in this strictest sense is not reassuring. Enrollments have fallen, costs have risen, and the problem of maintaining a sufficient scope and volume of work to support an adequate specialized faculty has become acute. However, is the idea of segregation sound in principle? How is a young man to determine in advance whether he belongs in the professional nucleus of engineering or in its general service functions? Will he find it out by prolonging his preliminary edu-

* Published in *Electrical Engineering*, May, 1935.

cation in an arts college? Can any vocational counselor or tester make the choice for him? Would employers of engineers respect it? I doubt it.

"Supposing the segregation could be made, however, would it be beneficial to future professional engineers to train them as a caste apart? Is not the presence in industry of a great body of scientifically intelligent and technically competent men an essential condition on which the purest of professional engineers must rely for the execution of his plans and schedules? Must not these two groups speak the same language, or understand each other sympathetically? Would a caste system of education work to that end? Can the division of functions come through any other process than natural selection at a mature age?

"When all the controlling factors are considered, it seems safe to estimate that the demand for strictly professional engineering service will diminish in volume, but will rise sharply in its qualitative standards. However, the demand for quasi-professional business activity in producing, distributing, and adapting technical goods and services may be expected to increase markedly.

"While an actual division of the field of engineering education between two types of colleges is seemingly impossible, it must be admitted that we are actually at the limit of our ability to accommodate a single educational program to both our professional and our general service objectives. A four-year undergraduate course rapidly is becoming totally inadequate as preparation for engineering service of a high professional type, yet it remains for the present a reasonably adequate basis for the great body of service activities for which young engineers are in active demand. It is, in fact, as advanced a type of education as industry and business in general are now able to capitalize. Furthermore, it approaches close to the saturation point for the great body of engineering students. A five- or six-year course for all students seems not only unwarranted and unwise, but highly desirable for a considerable minority, and virtually imperative for a selected few.

"What the American engineering college offers its undergraduate students is more properly called functional rather than professional education. Judged by this standard it probably is not surpassed in its effectiveness by any other undergraduate program. Its inadequacy as a professional discipline is scarcely open to question. In the present state of training and guidance, it seems inevitable that much of the process of selection between professional and general service objectives must fall within the college period rather than precede it. A common matrix of three years, as broadly humanistic and scientific as possible and only moderately differentiated between the major branches of engineering, should

suffice for this phase of preliminary selection. For men who purpose to enter the general service field, a terminal year, about equally divided between business subjects and some major technical division of engineering may be provided, while those who aspire to the professional field may pass at this point into a longer period of more profound and generalized scientific studies, with adequate attention to the techniques and problems of research, design, and application and with due consideration of professional relations and ethics.

"In a word, my ideal of professional education for engineers is not a separate route, but a second mile. In setting qualifying standards for the latter stage, all socially needful restrictions may be applied. The profession may sit as judge of standards and objectives without putting the colleges into a straight jacket. The Engineers' Council for Professional Development is adapted admirably to this function. Meanwhile the solidarity of the greater engineering fraternity may be preserved for the ideals of democracy and the larger service to our common life."

If I mistake not the most significant bearing of these developments in postgraduate education upon our undergraduate program is the experimental clarification of the relationship between an adequate professional discipline for engineers and a broad service training for the semi-technical requirements of industry.

## INDUSTRY AND THE GRADUATE OF ADVANCED COURSES

By GEO. B. THOMAS

Personnel Director, Bell Telephone Laboratories

The question is frequently raised whether the engineering student with an advanced degree gets employment more readily and how his advancement compares with the man with a bachelor's degree.

Since 1930 there have been lamentations about the scarcity of positions for college graduates. It is difficult to obtain a position but several studies indicate that the engineering graduates through persistence have been able to find jobs. Mr. Boring reported at the Electrical Engineering conference on Monday morning that he found in a study made last fall that the college graduates of the classes of 1931, 1932 and 1933 are rather consistently placed to the extent of approximately 60 per cent and that later studies indicate that over 57 per cent of the electrical engineering graduates of 1934 are satisfactorily placed. A study by Purdue University of their graduates from 1928–34 inclusive revealed that in 1929, 20 per cent found employment before graduation, an addi-

tional 60 per cent within two weeks and approximately 15 per cent more within three months. For the whole period 9.9 per cent found employment before graduation; 39.5 per cent more within two weeks after graduation and 23.7 per cent within three months after graduation. In other words, while in 1929 over 95 per cent found first employment within 3 months after graduation, the average over the years 1928–34 was 73.3 per cent finding employment within 3 months after graduation. In the fall of 1934 when the study was made 91.3 per cent of the graduates of the classes of 1928–34 inclusive were employed. This indicates that engineering graduates are overcoming difficulties and are finding employment. Employers looking for men tell me that it is difficult to find first-class applicants from the so-called depression year classes. Professor Leutweiler of Illinois had a request for some of his recent mechanical engineering graduates. He wrote the graduates of the recent classes and not finding enough prospects, he wrote to all his graduates from 1922–34, inclusive. Less than 6 per cent replied that they were unemployed. As there were prospects of employment, it seemed to him reasonable to draw the conclusion that all those unemployed and wanting work would reply. Of those replying, 62 per cent were employed and satisfied; 31 per cent were not fully satisfied with present positions and opportunities. These facts are given (in regard to the employment status of recent engineering graduates) as a background in considering the question if postgraduate training in engineering is an asset in getting placed and in future progress.

Letters were written to the deans or placement officers of the twenty engineering schools and universities which granted the largest number of master's and doctor's degrees in engineering in 1934. Replies were received from 17, representing close to 60 per cent of the master's degree group and over 95 per cent of the doctor's degree group. Recognizing the impracticability of getting statistical data, the letter of inquiry requested that the reply give such information as was available along lines of a submitted series of questions which were considered as merely suggestive. The replies were, on the whole, to the questions as submitted so this discussion will deal with the questions asked although it is recognized that they did not adequately cover the subject.

The first question was "Do Engineering students with postgraduate degrees get employment more readily than those with bachelor's degrees? Is the same thing true for the various branches of Engineering such as chemical engineering, civil engineering, electrical engineering, aeronautical engineering, etc.?"

The replies varied from the extremes of "Unquestionably yes" to "In most cases, no." Two out of three replies reported that

their experience showed that the postgraduate degree group has found employment more readily. Emphasis was placed upon graduate work being especially advantageous for teaching positions, for research and for distinctly engineering work. A number of replies stated that those with advanced degrees probably found employment more readily. Some qualifying statements were "Practically no difference for those with M.S. only," "Past experience indicated yes but case was completely reversed this year," "98 per cent advanced degree men placed as compared with 83 per cent bachelors."

The consensus of opinion was that graduate work in engineering is advantageous in obtaining employment for all branches of engineering. There was unanimity of opinion that it was of value in getting a position in chemical engineering and metallurgical and ceramic lines. The majority felt it was so in electrical and mechanical engineering while the most doubt was expressed in the case of civil engineering graduates.

The second group of questions was "Are the men with graduate degrees accepting positions formerly filled by men with bachelor's degrees? In other words, are they accepting positions in which there is no need or occasion to use the technical material and methods studied in the postgraduate years? If so, would the men continue to be happy on that type of work when industrial conditions improve?"

There was considerable feeling that the postgraduate degree man is accepting the type of position formerly filled by the bachelor degree man in former years. It was felt that this will not produce a problem for the future because being better qualified he will make better progress. One reply stated that employment standards are rising and another that some of the jobs were formerly filled by men with bachelor's degrees because of the shortage of men with graduate degrees. Still another reply raised the question whether in the adjustment to new conditions the individual might not have to find his ego satisfaction in his avocation.

The third set of questions was "Is there any indication that the graduate group has been diluted in ability by increases in registration resulting from inability to get employment? If so, is there any indication that this lower ability group improve their chances of getting a position by taking graduate work?"

About half the replies indicated that there has been dilution in ability along with the increase in registration since 1930. This dilution appears to be much less now than in 1931 and 1932. It was felt that even in those cases where there was dilution that those of lesser native capacity improved their employment chances by taking graduate work.

The question was raised "How does the engineering graduate with a B.S. degree who returns for further study in other undergraduate engineering courses or who takes some graduate studies without completing the requirements for an advanced degree fare in obtaining a position as compared with the man who has his B.S. degree only and with the man who has a graduate degree?" The replies showed that very few B.S. men have returned for undergraduate courses in other departments and that those who took graduate courses but did not fulfill the requirements for an advanced degree, did not improve their employment prospects appreciably.

There was nothing to show that any particular type of industry is especially active in employment. It is recognized that the larger industries are taking few men compared with the years previous to 1930. Government projects are employing quite a number of engineering graduates, especially civil engineers. The others are finding employment in smaller diversified industries. Starting rates have continued to decrease from 1929 until reaching a low in 1932 and have increased slightly since then. The increments in starting salaries between men with bachelor's, master's and doctor's degrees have also decreased. Estimates give the starting salary for a man with a master's degree in the neighborhood of $100 to $125 a year more than for the man with a bachelor's degree. Starting salaries for men with their doctor's degrees are less standardized but vary from $300 to $500 a year up more than for the bachelor's degree group. While these starting salaries are higher than for men with bachelor's degrees, the classmates of the advanced degree men who accepted employment at the time of receiving their B.S. degrees have usually advanced to a higher salary than the starting salary for the advanced degree classmate.

While the preponderance of opinion is that men with graduate degrees obtain positions more readily than those with bachelor's degrees, the replies emphasized that it must not be forgotten that success in life depends primarily on character, personality and native ability and that too much weight must not be placed on graduate study as being the major reason for advanced degree men getting placed more readily. It was pointed out that men taking graduate work are in general of superior qualifications and that they are more mature. One reply placed considerable weight on the fact that the faculty members are better acquainted with the graduate students and accordingly take a greater personal interest in them, resulting in their coming to mind more quickly when asked to recommend someone for a position. Apparently some new types of positions have been created in some industries calling for men with graduate engineering training.

Contact was also made with a number of industrial concerns. The consensus of opinion was that graduate work in engineering is an asset for research, design and highly technical positions but that it is not of measurable value in strictly operational, production and commercial positions. A greater percentage felt that the graduate group has been diluted in ability and that greater care must be exercised in selection. There is general agreement that the men who return to college after getting their bachelor's degree are better prospects for employment than the men who accept non-engineering employment until conditions pick up. The majority of men accepting non-engineering employment forget their engineering principles and are at a disadvantage when openings do come up.

As for future progress, there is some statistical evidence that men with graduate training make better salary progress in the creative branches of engineering but on the whole their progress in operational, production and commercial work is of the same order as that of men with bachelor's degrees. Men in the analytical and creative types of work who continue their studies rank in rate of progress with the men who received their graduate degrees before employment. Professor White, University of Michigan Chemical Engineering Department, gave some definite data in a paper he presented at Atlantic City in December, 1931. The table showed that at the end of ten years after receiving their first degrees, the median salary for men with the bachelor's degree was in the neighborhood of $3800, for men with one year of graduate work in the neighborhood of $4600 and for men with two years of graduate work in the neighborhood of $5400 in the research field. There also appears to be less turnover for men with graduate degrees. This is true for production and operation forces as well as for the research and development positions.

It appears that men with graduate engineering degrees are finding positions at higher starting compensation than men with bachelor's degrees. These starting rates in a given company are generally less than the current rate of engineers who received their bachelor's degrees at the same time but accepted employment instead of returning for further study. In work of a creative nature the men with graduate work appear to have made more rapid progress than the men with bachelor's degrees who did not carry on continuing study programs. There is not any data to support the theory that men with graduate degrees made more rapid progress in engineering work of the operational and productive type. However, the rate of turnover for men with graduate degrees has been lower than for men with bachelor's degrees. Will these same things be true for the advanced degree men who are being

graduated now in increasing numbers and are entering different kinds of employment? Only time will tell.

## GRADUATE WORK AND THE FACULTY

By J. W. Barker,

Dean, School of Engineering, Columbia University

It seems to me, in starting a discussion on the relationship of graduate work to the faculty, the statement which Professor Hammond read, and which is on page 15 of his report, as the concluding quotation in paragraph 5, sums up the general effect of graduate work on our faculties. The quotation reads: "The effect of graduate work has been revolutionary, stimulating the faculty and the interest of the students in their work."

Any method we can put into effect in our educational institutions which will accomplish those two things, stimulation of the faculty and an increase in the interest of the student in the work being presented to him, is certainly one of the most important things which could be undertaken in engineering education today.

This stimulation of the faculty I believe comes through at least two main points: Faculty members who are taking or who have pursued graduate work themselves, and having gone very materially deeper into the fundamentals of the subject which they are going to present to their student body in the undergraduate work, must of necessity have accumulated a greater background of theoretical training. They are then able to present the more important fundamental concepts to their undergraduate students in a far more interesting and effective manner than the man who is simply content to have carried on his own baccalaureate work, who has had some practical experience, and who comes back to expound to the student body the results of that work. The other point is mentioned very specifically in this report, and I should like to stress it as being in my opinion one of the ways in which graduate work will affect our faculties. It is on page 12 where Professor Hammond's Committee mentions what might be called the symposium type of summer session graduate work under outstanding leaders in particular specialties. We think immediately of Timoshenko and the group that is assembled around him in Michigan in theoretical and applied mechanics, about the group at Iowa State in hydraulics, etc.

I believe that those administrators and members of faculties who see the possibility of capitalizing their own peculiar situations with regard to staff, facilities and location, and build around those particular men a symposium type of postgraduate work leading to the Master's and Doctor's degrees in the summer, will bring to

their schools the junior members of our faculties who are desiring to specialize in that particular field and will spread the gospel throughout a larger number of schools than could be the case were we all to attempt to develop postgraduate work leading to the Doctor's degree in each of the various fields of work which we have in our curriculum in our various schools.

That the teachers are availing themselves of facilities for graduate work and personal advancement, leading to advanced degrees, is brought out very significantly by this report. I believe that the Committee is perfectly right in saying that the increase in the number of our faculty members who hold advanced degrees is not due so much to requirements of advanced degrees for appointment to the faculties as it is to the availability of qualified men with advanced degrees for additional appointments to positions on the staff. However, we must as rapidly as financial conditions permit make it possible for the junior members of our staffs to have the time available to pursue advanced work in their own particular fields.

If we continue to load assistants and instructors with eighteen, nineteen and twenty hours, as I know to be the case in some institutions, how can we expect a young man under conditions like that to advance himself in his own professional field? It is not fair to the man, and then if your institution for some reason or another imposes a requirement as to advanced degrees for promotion, you are simply condemning a youngster to routine, pot-boiling type of work. It is not fair to them and we must look forward to making it possible for those men to develop themselves. It is through self-development and not spoon-feeding that we are going to produce the engineering teacher of tomorrow.

I should like to touch briefly also upon the paragraph in Professor Hammond's Committee's report having to do with the conferring of advanced degrees on members of the institution's own staff. This is, of course, very complicated and I approach it with great trepidation. If we do not permit the junior members to take work in our own institutions we make it very expensive for them to carry on work to the advanced degree. On the other hand there are very great dangers in the path of any institution which permits members of its own staff to obtain advanced degrees under their own college. There most assuredly will come a situation where friendship and faculty associations, etc., will have an important bearing one way or the other on the question as to whether or not a man is given an advanced degree within his own institution. There are great dangers there and yet at the same time if we do not permit a certain amount of work by our junior members right on our own campus we make it particularly difficult for them to go on.

It seems to me, then, that there is a possibility for this Society to lead the way in what might be called intercollegiate recognition of advanced work. Most of us at the present time (I know my own institution does) have a residence requirement for any advanced degree. In effect that means that so far as the Master's degree is concerned no man can get any credit for advanced work pursued elsewhere toward the Master's degree at Columbia because he must carry on a year of advanced work at Columbia in order to get any degree, and the one year of work is a requirement for the Master's degree.

I believe that if one of our young men has done some work at M. I. T., for instance, or Michigan, or any other well recognized school and he comes to our faculty, or, the reverse, he does some work with us and goes to M. I. T. or Michigan, there should be some arrangement by which those credits can be transferred without complete application of the resident requirement. That also has certain dangers. I am not offering it as a cure-all. It has many dangers. You do not need to have them pointed out to you. They exist, but certainly wise consideration and a coöperative frame of mind on the part of the administrative officers having to do with the admission of candidates for awarding of advanced degrees can lead us along the path of doing the fair thing by our younger men and at the same time holding the degree which we grant in our own institution completely within our own hands.

### Discussion

**Thorndike Saville** (New York University): As a member of the Committee I want to say how grateful the majority of the Committee ought to be—are in fact—to Professor Hammond for the work which he has done. Like most committees the majority of the work has been done by the Chairman, and Professor Tucker and Mr. Thomas have also contributed very largely. The rest of us, I am sorry to say, have done very little.

There are one or two matters which I am hoping the Committee may see fit to carry on as it continues its work, which I hope may be done in order that they may promote a more complete report next year.

In the report mention is made of the number of institutions offering work for the Doctor's degree. It is stated that there are thirty such institutions. Personally I question very much whether there exist in the country thirty engineering schools which are properly equipped to grant the Doctor's degree. I think that is a matter which the Committee should discuss and make some commitment upon.

As a way out of the situation which is developing due to the trend toward increases in numbers of advanced degrees, including Doctor's degrees, it seems to me that the situation which was touched upon with respect to visiting professors ought to be amplified more. Another subject is the situation with respect to cooperative agreements. There is a coöperative agreement of a sort in effect between Harvard and M. I. T. which is most promising. There is an agreement of somewhat less formal proportions—an understanding, let us call it,—between certain institutions in the New York area. That to my mind is going to provide a way out whereby advanced degrees both of the Master type and of the Doctor type can be granted with a very much better background of really advanced training by competent staff members than if each individual institution tries to run the whole gamut of the advanced degree situation by its own staff alone.

Another matter that I think should be called to your attention relates to the trend whereby the five-year course situation seems to be getting its answer through the increase in candidates for master's degrees, but a word of caution is in order there to my mind. Master's degrees have been and are of two quite different types. They have been granted and are being granted on the one hand for really advanced work, including research work of some consequence and a thesis. On the other hand they have also been granted and are being granted for purely additional curriculum courses, somewhat more advanced or somewhat more detailed in character than the related undergraduate courses.

There is a question, and one which the Committee with the help of the members of the Society should consider, as to whether some distinction should be made between these two types of courses, one which is to my mind of a really graduate character, and the other which is of a more or less service character. The service character course is in increasing demand not alone for the degree but as supplying a real need upon the part of the men who are employed, which brings us to the situation that Professor Hammond described in the report about which so much is being done so well at Brooklyn Polytechnic Institute; the provision of graduate work in the evening for employed engineers. A great many of these men do not actually need the master's degree, and to my mind many of them ought to be encouraged not to become candidates for an advanced degree, but on the contrary to take certain of these advanced courses which to be sure are perfectly good courses to be credited toward the master's degree but which these men need only in connection with the specific work in which they are engaged. The tendency is often after having taken one or two of these service courses of an advanced nature, which they

really do need, to become unduly ambitious to go ahead and just for the sake of getting a master's degree to take a lot of graduate courses which sometimes are not of a really graduate character and oftentimes which they do not really need in connection with their work.

**Vice President Hammond**: The topic of graduate work is open for further discussion.

**C. J. Freund** (University of Detroit): It is generally taken for granted that some kind of research work must be the foundation upon which graduate studies are built. It is generally assumed, too, in many quarters at least, that research results must be published to the world. A good many of our schools do a very fine type of research work which leads, however, to a confidential report for some corporation. Has the Committee a policy, or even an opinion, regarding the extent to which such very proper investigative work, leading, however, to a private report, may be made the basis for graduate work in a college?

**Vice President Hammond**: The Committee has a general division of its study entitled "The Fundamental Nature of Graduate Work," but this does not include the particular problem you have in mind, which has been discussed, to my knowledge, on a great many occasions, with reference to patent rights, for example, resulting from a research project. I think it would be difficult for our Committee to include that particular topic in its studies at this time.

**D. C. Jackson** (Massachusetts Institute of Technology): Dean Freund's question, as the Chairman has said, is one that would be very difficult for his Committee to answer, it has been discussed so much in college circles and in other circles, but perhaps there ought to be added to the statement that the Chairman has made, the statement that the matter has been under consideration for a number of years with decisions that have been somewhat vacillating by the National Research Council and a committee thereof that have made reports. If Dean Freund wishes to get the latest information about that he might write to Washington, to the Secretary of the National Research Council, at the National Research Council Building, and he will get a full statement of the discussions as to the present state of opinion of that situation. That is perfectly appropriate for us to consider because the National Research Council is not only made up of divisions representing the various separate branches of science, but it includes a Division of Engineering and Industrial Research, which is one of the influential divisions of the Council, and that Division has had its full share of weight in these discussions and opinions that have been formulated.

I want to congratulate Professor Hammond, the Chairman of the Committee who has just made the report and his Committee on the admirable character and on the importance of the formulation of their report. I believe that we are most fortunate in having come to the point in regard to this particular situation in engineering education at which such a report can be produced. I doubt very much whether four or five years ago such a report could have been produced because there would not have been sufficient unity of opinion, and I say that with a lot of observation and experience because I have been associated with the teaching of graduate students as well as undergraduate students for a great many years. I began in electrical engineering with graduate work as much as thirty-five years ago, and at the present time there are men who have taken masters' and doctors' degrees in work that was subjected to my administration that aggregate perhaps 800 students of whom perhaps 5 per cent have taken doctors' degrees. That has led me to be in constant observation on the matter. We have not heretofore come to any reasonable unity. This report ought to bring us to unity.

My views may be right or wrong. I think they are right, of course, but you may not agree to that, but at the same time my views are known, or at least they can be readily known, and it is on the basis of that sort of experience, that sort of consideration, that sort of reflection that has led me to my views and that has made me willing to put them down on paper, that makes me say that this report in my opinion is one of the very important developments that is being laid before the Society. The prepared discussions are likewise of very great importance; for instance, the emphasis that Dean Barker put upon the consideration of policies within the institution with respect to its younger members of the staff. My own policy has been to try to unload the younger members and then require them to do creative study of a formal nature. I do not care whether a man has an advanced degree or not, but I do care whether he has the achievement that might lead him to an advanced degree, and if a younger member of the staff will not do adequate advance study for himself for his own benefit then he is not serving our needs effectually. And our problem there is to get a sufficient staff so that the younger chaps may be unloaded with respect to the innumerable hours of drudgery that are commonly loaded upon them.

Then again this question of institutional interrelationship, and that was referred to by Dean Barker as a very important matter, and if we can get into that development more effectually I believe it may be very helpful to engineering education. My own department is exchanging year by year an assistant professor with

some other department of electrical engineering in another engineering school. We have only done it one year, but it has proved very successful that year and we have made our exchange arrangements for the succeeding year, and already have applications from various institutions saying they would like to make an arrangement for the year after. So that it looks like it will be successful, and as far as the present year goes it has been very successful. That is the man who came to us gained advantages for himself and his institution and we gained advantages by having him. The man who went to the other institution I am sure gave something to the other institution, at least they say so, and I am sure he gained advantages that will be of service to himself and to us.

I would put that up as one of the things to do with the younger men. It should be the younger men of the assistant professor rank who will bring back something that will serve to stimulate him and be serviceable for a period of years.

There is another feature that is very important in this situation, and Mr. Thomas has stirred that up. It is rather interesting to call your attention to the fact that of the five men who gave prepared discussion, Professor Tucker, Dean Barker, President Wickenden and Mr. Thomas have either been colleagues or students of mine, and, of course, I think well of their views but I do not wholly agree with any of them. A man who agrees with me who is my student is not a good student. A colleague who agrees with me in all things and cannot bring new ideas that I have not formulated so that we may consider them is not a satisfactory colleague. So I do not agree with everything that was said by these chaps.

Mr. Thomas has brought up a point that I want to emphasize. It is a fact that we are lacking very much in proper coördination between the engineering schools and their personnel relations with the personnel divisions and representatives of industries. The situation of securing young men for industry from our classes during the boom times was most unhappy. It was disadvantageous to the engineering schools and it is my opinion it was disadvantageous to the students, the ultimate life I mean, and, therefore, disadvantageous to the industries.

There is not enough distinction (this is where I disagree with Mr. Thomas or maybe this inference ought not to be held) made between the young man who has only taken a Bachelor's degree and the young man who has the courage to spend time and money in more advanced study, provided the faculty of the institution at which he is studying is satisfied to have him as a graduate student because they believe it will be to his advantage. That matter should be worked out so that the differential will be fair, and possibly the differential as to immediate salary need not necessarily be

made larger, but it should be considered, and the question of the rate of promotion should be considered.

If good times come again and we fall back into our old relations between representatives of industry and students we are going again to get into a situation that is disadvantageous. So I invite Mr. Thomas, as the representative of a very eminent organization, to think this over and see whether the industrial representatives cannot get together on some sort of a mutual ground and work out a plan so that their recruitment will be advantageous rather than disadvantageous to the engineering school situation. Maybe some of you do not agree with me that it has been disadvantageous. That is just a question of my opinion against yours, but I believe that our experience supports my opinion.

## RESEARCH AN INSTRUMENTALITY IN ENGINEERING EDUCATION

### REPORT OF COMMITTEE ON ENGINEERING RESEARCH

Although a survey made by your committee indicates that cooperative research, supported by industry and particularly by the public utilities, has not yet regained its normal status during the year, yet much valuable research, outlined in brief in the appendix of this report, has been accomplished.

While at some institutions the feeling still obtains that independent, pure research, financed from general educational budgets or those allocated to research by the board of regents or the legislature as the case may be, are preferable because of their alleged independence of action it is believed that the consensus of opinion, particularly among those institutions which have given coöperative research a thorough trial, is to the effect that the industrial coöperative research and development are of peculiar value for the following reasons:

1. The student and staff director are brought into intimate contact with the personnel and the practical engineering problems of timely interest and value to industry with which the student and the up-to-date instructor must necessarily deal in the near future.

2. The funds available are usually more nearly adequate for the purpose and do not tend to deplete educational budgets.

3. The equipment purchased, donated, or constructed for a specific research project is frequently of permanent educational value and is usually retained by the educational institution, thereby becoming available for instruction or varied research after the particular investigation has been completed.

4. The training of students and the younger staff members in methods of precise and periodical recording and reporting upon research, involving a rigorous daily log of progress (a feature so frequently omitted in academic research) has been found to be invaluable for it has usually been required by the industrial parties involved in such coöperative investigation.

5. The experience usually resulting from intimate contact with patent technique and patent law, which is necessarily gained upon a much more practical and more rigorous régime than with aca-

demic research, is a very valuable training for all parties associated therewith.

6. The relative preliminary costs of patent applications and the ultimate values, or lack of values, of the patents frequently resulting from such developments are strikingly demonstrated to the prospective young inventor without serious loss to himself as an individual.

7. The correlation of theory and *practical practice* is more thoroughly, more promptly and more conclusively demonstrated by this means to the staff member and student than by any other known method. Such are immediately reflected in his subsequent teaching or engineering development.

Thus it appears that these values, which have been experienced by those institutions which have undertaken such coöperative research, not to enlarge upon corresponding values to industry, should inspire other educational institutions to initiate negotiations looking toward such coöperation during the forthcoming revival of industrial relations.

Although many such projects are to be found briefly listed in the appendix of this report, with such references as may be convenient for further investigation by those interested, the chairman of your committee upon this project assumes the liberty, frequently conceded to such an office, to emphasize briefly three recent projects and their unique favorable results with which he has been associated at Purdue University.

Television, an outgrowth of early cathode-ray oscillograph research directed by Professor R. H. George, supported as it was at first by the Grigsby-Grunow Co. (Majestic Radio) of Chicago and subsequently by RCA, has provided all of the advantages enumerated above, has resulted in a commercial television receiver nearly ready for quantity production, several valuable patents for which the University and its staff will receive royalties, a substantial financial recognition and a continuation of research annuities.

Secondly, the investigation extending over a period of two years, of new methods of lightning protection of standard electric light and power distribution systems under the direction of Mr. C. S. Sprague and supported by the Utilities Research Commission of Chicago which resulted, aside from the above mentioned values, in Experiment Station Bulletin No. 42 entitled, "Lightning Protection of Distribution Systems and Transformers." This describes a new interconnection of transformers which, according to Mr. D. W. Roper,

> The effects of interconnections on troubles due to lightning in Chicago were,

| Reduction in rates of troubles due to use of interconnection as follows: | 1932 | 1933 | 1934 |
|---|---|---|---|
| Transformers burned out | 60.4 | 63.9 | 57.4 |
| Fuses blown | 67.0 | 65.0 | 74.2 |

More recently should be listed the unique housing project, only this month launched by a most appropriate address at a Research Foundation Conference at Purdue University by Mr. Owen D. Young. This, the dream of Mr. David E. Ross, President of the Board of Trustees, is rapidly maturing into a very comprehensive industrial coöperative endeavor for the building and testing of some twenty typical houses to be occupied and experimented upon by the coöperating staff researchers themselves to determine the most economical, the most durable and the most liveable of modern homes and home appliances. In addition a laboratory, sufficiently large to accommodate several complete houses has been planned within which not only building materials but complete buildings may be subjected to accelerated weathering exposures in order to determine in a relatively short life cycle their all-around usefulness and probable life.

This is an adaptation, upon a very large scale, of the accelerated weathering tests which were carried out, with the industrial cooperation of the Utilities Research Commission, during a period of three years in connection with the study of possible increased life of weatherproof wire. Accelerated weathering throughout a predetermined duty cycle, consisting of freezing, thawing, high temperatures, artificial sunlight and rain provided in six weeks the equivalent of twelve or more years of natural exposure to weather. As the result, all wire manufacturers are now producing this new long-lived wire, a standard specification has been established, Bulletin No. 43 describing this research process has been published and staff, students and the industry have all profited greatly thereby.

Since the personnel of the committee represents a very good cross section of the engineering educational institutions of the country, the following research projects which have been listed in the Appendix by the members of the committee as being active in their organizations may be of interest. In so far as information was available, the coöperative projects have been designated by the asterisk (*).

Anticipating further inquiries regarding the details of these projects and particularly the means used to avoid legal difficulties with such, a brief description of the work of all which have been listed and a sample contract form used for such at the University

of Illinois are included in the files of the Committee to which reference may be made by any members particularly interested therein.

Furthermore, in conclusion, Director Holland of the National Research Council has submitted as a part of the Appendix to this report some very pertinent comments from executives in industries who have had considerable experience with coöperative research which set forth some of the difficulties to be overcome in undertaking such projects upon a large scale.

It is evident that these difficulties pertain more to pure academic research of a highly confidential and competitive nature than to engineering development carried on by engineers within the profession and that the legal, patent and royalty hurdles have been adequately cleared by means of such intermediary organizations as Engineering Experiment Stations and Research Foundations which are most effective at the institutions within which the largest amount of successful coöperative research work is being carried on. Studies based upon personal inspections of such Research Foundations as exist at Purdue University and a few other engineering colleges, particularly in the Middle West, are gradually resulting elsewhere in the inauguration of other similar plans to overcome the legal and financial difficulties listed in the Holland report and it is believed that in the near future, industries, public utilities and engineering colleges may go forward together in the development of the engineering profession to the mutual advantage of all concerned.

C. F. HARDING, *Chairman*
Read by G. C. BLALOCK
*Committee on Engineering Research:*
C. F. HARDING,
C. H. BERRY,
H. C. BERRY,
O. G. C. DAHL,
F. E. GIESECKE,
W. B. GREGORY,
G. L. LARSON,
F. T. MAVIS,
H. F. MOORE,
C. T. MORRIS,
S. TIMOSHENKO,
B. R. VAN LEER,
F. B. JEWETT,
C. B. VEAL

## APPENDIX

*Active Research Projects as Reported by Members of the Committee on Engineering Research*

### UNIVERSITY OF PENNSYLVANIA

*Department of Civil Engineering*

Research on Wind Stresses in Tall Buildings
Flow Nozzle Tests for General Electric Company
Pitometer Test for Pitometer Company of America
Calibration of 12″ × 8¼″ Venturimeter and Test of Centrimax Integrator for Leeds and Northrup. Condensate meter for Richmond Station of P.E. Company
Tests of 8″ × 3⅜″ Venturimeter for Influence of Installation
Test of Flow Nozzles for Fluid Meters Committee of A. S. M. E.
Comparison of Volumetric and Weighed Discharge Measurements in Hydraulic Testing

*Department of Mechanical Engineering*

Investigation of Methods of Photo Elasticity
Investigation of Certain Types of Anti-Friction Bearings

*Chemistry and Chemical Engineering Department*

*About thirty-six research projects on theoretical chemistry by members of the staff

*Department of Electrical Engineering*

Development of a Differential Analyzer for the Mechanical Solution of Non-Linear Differential Equations
Development of a Sound Prism for Electrical Analyses of Sound
*Improvement of X-Ray Apparatus
Development of an Algebraic Equation Solver Capable of Determining Both Real and Imaginary Roots
Development of High Voltage Generator
Several members of the staff are engaged in purely mathematical research in advanced electric circuit theory as applied to the solution of electrical network problems.

### AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS

*Engineering Experiment Station*

*A Study of the Value of Butane as a Fuel for Internal Combustion Engines, in Coöperation with the Lone Star Gas Company
*The Chemical Precipitation of Sewage, in Coöperation with the City of Dallas
*The Self-purification of the Trinity River, in Coöperation with the City of Dallas

* Definitely reported as Coöperative Projects.

*A Study of the Treatment of Dairy Wastes, in Coöperation with the City of Waco and with the Borden Milk Company
*A Study of the Underground Water Resources in Southwest Texas, in Coöperation with the Missouri-Pacific Railroad, the Texas State Board of Water Engineers, and the U. S. Geological Survey
*A Study of the Heat Losses of Buildings, in Coöperation with the A. S. H. V. E.
*A Study of Certain Types of Welded Joints, in Coöperation with the Wyatt Metal and Boiler Works
*A Study of Summer Cooling, in Coöperation with the Johns-Manville Company and the Portland Cement Association
A Study of the Biological Treatment in Water of Settled Sewage, in Connection with the Operation of the A. & M. College Sewage Treatment System
A Study of the Purification of Sulphur Water, in Connection with the Operation of the A. & M. College Water System
A Study of the Acoustics of Buildings
A Study of Radiation from Various Surfaces
A Study of Stresses in the Reinforced Concrete Pavement Slabs
A Study of Early Land Surveys in Texas
Effect of Stream Pollution on Fish Life
A Study of the Distribution of Soil Pressures on Building Foundations
A Study of the Spinning Values of Cotton and Other Fibers
A Study of the Treatment of Laundry Wastes
A Study of the Effect of Brewery Wastes on Sewage Treatment
A Study of the Pressures under Retaining Walls

UNIVERSITY OF MICHIGAN

*Department of Engineering Mechanics*

*The Effect of Surface Cold Work on Fatigue Strength of Cylindrical Specimens
*Thermal Stresses in Plates
*Surface Fatigue in Rollers

"Our experience shows that coöperation with industry, consisting of taking for Doctor's thesis problems of practical interest which can be financed by industry, is a very useful arrangement. In this way the University can expand its laboratory equipment and can organize extensive experimental research work without great expense to the University. Also a close contact with industry can be established which may be useful in placing graduate students."

UNIVERSITY OF ILLINOIS

*Engineering Experiment Station*

*Stresses in Railroad Track, in Coöperation with the A. S. C. E. and the A. R. E. A.
*Problems in the Mining of Coal, in Coöperation with the State Geological Survey Division

*Warm Air Furnaces and Furnace Heating Systems, in Coöperation with the National Warm Air Heating and Air-Conditioning Association

*Cast Iron Pipe, in Coöperation with the Sectional Committee on Specifications for Cast Iron Pipe

*Solubility Studies of Boiler Waters, in Coöperation with the Utilities Research Com.

*Stack Gases, in Coöperation with the Utilities Research Commission, Inc.

*Study of Creep and Fracture of Lead and Lead Alloys used in Sheathing for High Voltage Cables, in Coöperation with the Utilities Research Commission, Inc.

*Heating and Ventilating, in Coöperation with the American Society of Heating and Ventilating Engineers

*Reinforced Concrete Arches, in Coöperation with the U. S. Bureau of Public Roads, the American Society of Civil Engineers and the Engineering Foundation

*Causes and Prevention of Transverse (and other internal) Fissures in Railroad Rails, in Coöperation with the American Railway Association and the Rail Manufacturers' Technical Committee

*Sound Absorption by Materials, in Coöperation with the United States Gypsum Company

*Reinforced Brick Masonry, in Coöperation with the Reinforced Brick Masonry Board

*Methods of Cleaning Coal, in Coöperation with the Franklin County Coal Company, Inc.

*Boiler Scale Studies, in Coöperation with the National Aluminate Corporation

*Determination of the Magnetic Moment of Hydrogen, in Coöperation with the National Research Council

*Summer Cooling, in Coöperation with the American Society of Heating and Ventilating Engineers, the National Warm Air Heating and Air Conditioning Association and others

*Rigid Frame Structures, in Coöperation with the Portland Cement Association

*Rigid Welded Joints, in Coöperation with the Research Committee of the Chicago Section of American Society for Welding Engineers and others

*Strength of Chilled Car Wheels, in Coöperation with the Association of Manufacturers of Chilled Car Wheels

*Resistance of the Treads of Chilled Car Wheels to Heat Checking, in Cooperation with the Association of Manufacturers of Chilled Car Wheels

*Monolithic Concrete Walls, in Coöperation with the Portland Cement Association

*Pressures in Granular Materials, in Coöperation with an Anonymous Donor

*Steel Columns, in Coöperation with the New York, Chicago and St. Louis R. R. Company

*Reversed Stresses on Riveted Connections, in Coöperation with the State of California

*Velocity Selector for Atomic Rays, in Coöperation with the National Research Council
Effect of Dissolved Gases on the Softening Temperature of Glass
Method of Testing the Corrosion of Glass Furnace Refractories
Specific Heat of Molten Glass
Surface Tension of Glass
Aerogel Catalysts
Catalytic Oxidation of Organic Compounds
Electrolytic Reductions
Free Energy Studies
Belt Line Traffic Survey (F. E. R. A. project)
Bituminous and Non-bituminous Joint Fillers
Digestion of Garbage With Sewage Sludge
Distribution of Concentrated Loads by Timber Floors
Experimental Study of Laminated Timber Arches
Flood Flow Studies of Illinois Streams
Highway Signs
Sheffield Paddle Aeration in the Activated Sludge Process of Sewage Treatment
Stress Distribution Among Rivers of "Split-H" End Connections for Wind Girders
Detailed Study of Coal Mine Ventilation
Study of the Utilization of Illinois Coal-Mine Wastes
Boring Tools and Twist Drills
Determination of Pinion Proportions and Keyway Location by Photo-elastic Study of Stress Distribution
Durability of Molding Sand
Radiometric Study of Explosions in a Gasoline Engine
Absorption and Magnetic Rotation Spectra and Heats of Dissociation of the Alkalis
Antiseptic Treatment of Northern White Cedar Posts and of Timber Used in Freight Car Construction
A Study of the Action of the Exhaust Jet Within the Front End of Steam Locomotives
Brake Shoe Friction at High Speeds and at High Pressures
The Effect of Car Distribution on Train Resistance
Tractive Effort of Steam Locomotives
Train Resistance of Railway Cars at Starting and at Low Speed (F. E. R. A. project)
Fatigue of Metals, various problems, including problems of stress-concentration and design of testing machines
Plastic Flow of Concrete
Plaster-Model Method of Stress Analysis
Methods of Calibration of Testing Machines
Comparison of Methods of Testing Polyphase Watthour Meters
D.C. Corona Discharge in Wires at High Voltage
Detection of Small Changes in Frequency for Power Plants
Dielectric Strength of Porcelain Under Mechanical Stress
Effect of Intermittent Load on the Accuracy of the Watthour Meter

Electrodeless Discharges
Electron Oscillations
Television Transmission-Scanning Living Subjects
Oscillations Due to Corona Discharges
Radio Frequency Attenuator Design
Effect of Magnetic Fields and Harmonics on Accuracy of Watthour Meters
Study of Design and Characteristics of Rectifier Tubes and Amplifiers
Investigation of Study Lights, Desk Lights and Class Room Lighting

UNIVERSITY OF FLORIDA

*Department of Mechanical Engineering*

Investigation of the Centrifugal Force and the Resulting Radial Movement of Air in Aircraft Propellers
Utilization of Solar Energy for Refrigeration and Air Conditioning in Florida

*Department of Electrical Engineering*

Design of a Simplified Electric Stroboscope
Location of Hurricanes by Means of Static Direction Finders
General Study of Atmospherics

*Department of Civil Engineering*

A Study of the Imhoff Tank Trickling Filter Sewage Disposal Plant
Finding Faults in Telephone Cables

THE TULANE UNIVERSITY OF LOUISIANA

*Department of Electrical Engineering*

Study of Characteristics of Ionized Air Over Temperature, Frequency and Pressure Ranges

*Department of Mechanical Engineering*

A Proportional Meter for Obtaining Direct Reading, viz.: For Miles per Gallon in Automobiles; Pounds of Steam per Pound of Fuel in Boiler Plants, etc.

*Hydraulics Department*

Losses at Entrance to Pipes. Pitot Tube Studies

*Chemical Engineering Department*

Ph Control of Water Purification, Using the Line-Iron Process

*Physics Department*

Investigation of Thermionics
Study of F.P. 54 Tubes with Special Reference to Humid Locations

OHIO STATE UNIVERSITY

*Wear of Metal in Ceramic Plants
*The Secondary Expansion of Ohio Flint Fire Clays
*Fillers for Paving Brick
*A Study of Brick Manufactured by the De-Airing Process
Researches in Dry Press Refractories
The Study of "Spit-out" Causes in the Firing of Decorated Ware—Station project
Frizzled Decal—Station project
*Bonds for Sillimanite Brick
*Freezing Pyrometric Cones
*Elimination of Iron Oxide from Pyrometric Cones

UNIVERSITY OF WISCONSIN

*Department of Hydraulic and Sanitary Engineering*

Investigation of the Effect of Viscosity and Surface Tension on Triangular Weir Coefficients
Investigation of Effect of Viscosity on Venturi Meter Coefficients
Use of Combination Air Separator-Booster and Re-Lift for Pumping Fluids With the Air Lift
Hydraulics and Pneumatics of House Plumbing
Model Experiments on Erosion Control Structures
Water Hammer Investigations
Hydraulics of Filter Sands
Oxygen Demand of Sewage Sludges

*Department of Electrical Engineering*

Control of the Distribution of Heating Currents by the "Proximity Effect."
Control of the Conduction of Electricity Through Gases and Vapors
Split-Phase Starting of Three-Phase Induction Motors
Double Synchronous Speed Induction Motor

*Department of Applied Mechanics*

The Effect of Repeated Understressing and Overstressing on Iron and Steel
The Use of Plaster Models for Predicting the Strength of Metal Specimens and of Plain and Reinforced Concrete Structures
*Freezing and Thawing Tests of Cement Mortars
Tests on the Effects of Vibration in Placing Concrete of Low Cement Content
Tests on Mortars Suitable for Reinforced Brick Masonry Construction

*Department of Mechanical Engineering*

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HARVARD UNIVERSITY

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Theoretical Investigation of the Consolidation Characteristics of Clays
Experimental and Theoretical Investigation of the Effect of Temperature on Consolidation of Clays
Experimental and Theoretical Investigation of frost Action in Soils
Experimental Investigations of the Stress-Strain Characteristics of Clay Beneath Footings and Its Relation to the Stress-Strain Characteristics of Unconfined Soil Cylinders
Study of the Trends in Design Characteristics of Modern Highways
Theoretical Investigation of Seepage Through Earth Dams
Lag Effect in Vacuum Tubes and the Complex Tube Coefficients
New Method of Measuring Resistance at very High Frequencies
Investigation of a New Generator of Centimeter Waves
Effect of Harmonics on the Power and Efficiency of Vacuum Tube Oscillators
Amplification of One Frequency by Power Amplifiers as Affected by the presence of a Second High Energy Component of Another Frequency
A Study of the Gradient at Which Ionization Begins in High-voltage Paper-insulated Cables
A Study of the Combined Electrical and Mechanical Characteristics of Suspension Insulators
A Study of the Potential Distribution in Insulating Oil by Means of Polarized Light
Stability of Mechanical Systems Under the Influence of Hydraulic Flow
Forced Vibration of Non-linear Spring Combinations
Membrane Analogy of Potential Flow in Hydronamics
Relaxation in Copper
Residual Stresses in Welded Steel
Cleaning of Dusty Air by Filtration
Minimum Ventilation Requirements
Chemical and Petrographic Analyses of Fine Dust Particles
Hazards Connected with Electric Welding
Studies on the Flow of Water Through Sand
Studies on the Digestion of Sewage Solids
Studies on the Viability of Bacteria in Air and the Control of Air-borne Bacteria
Studies in the Measurement of Odors
Automatic Control of Rectifiers
Dynamic Properties of Iron
Phenomena in Grid-controlled Mercury Arcs
D.C. Amplifier, High Current Output
The Zoning of Mineral Deposits in the Organ Mountains of New Mexico
Depth Changes in the Butte Sulphides
The Opening of Fissure Veins
The Geology and Ore Deposits of Cerro de Pasco, Peru

A Comparison of Stresses in a Statically Indeterminate Framework as Found by the Algebraic Method and by the Use of Celluloid Models
A Study of the Effect on the Reactions of a Change in Cross Section of a Member in a Statically Indeterminate Framework
Dust Control in Rock-drilling, Foundries
Study of the Characteristics of Dust-sampling Instruments
Design of Local-Exhaust Hoods
The Recording of Kennelly-Heaviside Layer Radio Echoes at Distant Points
Field Measurements on Short Wave Radio Transmission
Polarization of Radio Waves Returned from the Ionosphere
Experimental Investigation of a Superregenerative Receiving Set
Transient Oscillations in Electric Filters
Characteristics of Light Valves
Crystal Filters
Scattering of Cosmic Rays
Fluctuation Noise as a "White Light" Source for Electrical Measurements
Torsional Properties of Steel at Room and at Elevated Temperatures
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Color Carbon Determination as Influenced by Particle Size
Heat Treatments of White Cast Iron
The Design of a Multivibrator-Amplifier-Equalizer-Filter Combination for the Production of a Complex Wave Consisting of a Group of Harmonically Related Waves of Approximately the same Amplitude and an Examination of the Behavior of Certain Networks with this Wave Impressed
Separation of the Heat Transfer from a Surface into Its Separate Components of Convection and Radiation
Investigation of (*a*) Drop and Film Condensation of Steam on a Copper Surface, and (*b*) Measurement of Surface Temperature Under Those Conditions
Investigation of Thermal Conductivity of Several Liquids, and Analysis of Equations in That Field
Investigation of Temperature and Velocity Distribution in a Liquid Inside a Copper Pipe Through Which Heat Is Passing
An Investigation of the Lattice Parameter Changes in an Aging Copper-Nickel-Silicon Alloy
A Study of Certain Age-Hardenable Silver Alloys
A Preliminary Investigation of the Iron-Columbium System
The Electrical Conductivity of Duraluminum While Aging Under High Hydrostatic Pressures
Effect of Physical and Chemical Agents upon the Viability of Microscopic Organisms Suspended in Air
The Reignition of an Arc at Low Pressures
Investigation of Combustion Phenomena by Infra-red Radiation Method
Research on Street Traffic Problems
Amplifier and Thermocouple for Measurement of Radiation
Measurement of Contact Potentials and Surface Heat
Measurement of $e/m$
Measurement of Mass of Ions and Excitation Function

## MECHANICAL ENGINEERING

By F. W. MARQUIS

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"Research, if you have not already discovered this about it, is one of those subjects that everybody is willing to talk about on all occasions. It means lots of things to lots of people. Some stress the first syllable and thereby earn the contemptuous regard of those who save the accent for the second. Frequently a qualifying adjective—scientific, sociological, industrial, or even pure—is used to delimit the field. In academic circles one savant will tell you in confidence that that blundering idiot on the other side of the campus is attempting to call the routine testing or commercial investigations he is making, research. Another will say that so and so thinks what he is doing is research because he is rediscovering what every one else already knows. Certain researchers spend all their time in libraries, others amid an impressive clutter of glass tubing and electric circuits; still others find it necessary to travel to distant places and paw over the dust heaps of lost cities. Some ascend to the stratosphere and others let themselves be lowered into the eternal darkness of dark waters. Some sit with eye glued to microscope or telescope, while others juggle mathematics. Some use guinea pigs, some humans, and others inanimate materials. But everybody talks about research; college presidents who want endowments, heads of corporations who are looking for new industries, newspapers and magazines that attempt to popularize science, and editors eager to pay tribute to men who discover truth instead of always writing about the spirit of wisdom and understanding."

The above is quoted from an article entitled "The Ways of Research" which appeared in the American Society of Mechanical Engineers' *Student Branch Bulletin* of January, 1935. It is repeated here because it gives such an interesting picture of the breadth of research, of its far-reaching possibilities in many different directions, of the wide variety of opinions that are held concerning it by different people, and of the serious danger of misrepresentation and exploitation of special interests being carried on under its name.

Research is at the very root of engineering and engineering education. Engineering has been defined as "the scientific utilization of the sources and materials of nature in the construction, production, and operation of works for the benefit of man." How can the forces and materials of nature be scientifically utilized unless nature's laws concerning them are known, and how can nature's laws be discovered except through research? Of course many of

these laws have already been discovered, but there are so many instances in connection with the teaching of any applied engineering subject where knowledge is so evidently incomplete, that an emphasis on the meaning and need of research would necessarily and naturally be given as a part of the teaching of such a subject. In fact, it is difficult to see how even undergraduate engineering teaching could be done without the student obtaining an idea of research, its function and importance. Moreover, this idea should not be that it is something apart and hallowed that has to be done in secret behind closed doors, but that it is an important function or tool which every engineer should use wherever needed and possible. Sometimes a comparatively simple and easily performed investigation, done by an engineer who has other duties, and in connection with these other duties, will enable him to solve some problem which confronts him. Also, of course, some researches can be carried on only by specially trained men who devote their entire efforts to the work over long periods of time and who have elaborate and expensive apparatus at their disposal. But in undergraduate teaching the important thing is to give the student some conception of what is meant by research, of what has been and can be accomplished by it, and a realization that it does not always have to be difficult and complicated, but that often simple and easily performed investigations may be valuable and important. The importance of developing an enquiring mind, which is continually looking for new information, and for new methods of doing things, instead of taking for granted older and previously developed methods as being the best and only ones, should also be emphasized. And it should be possible to do this without any formal or definite course of study having to do specifically or primarily with research.

At the present time it is becoming increasingly difficult to find room for adequate treatment of the many subjects which are considered as absolutely essential in an undergraduate curriculum in the time available. This situation has caused the serious discussion of the five year vs. the four year curriculum. It is also continually causing the revision of many curricula, and the elimination of some subjects to make room for others deemed more important. One of the things which has been removed as a requirement from some undergraduate curricula is thesis. It seems to be the opinion in some quarters that many undergraduate seniors will find greater profit by following the more closely supervised routine of a regular course than they will from the thesis, and also that even without the formal thesis there is much opportunity, as pointed out above, to give the undergraduate student some conception concerning the meaning and importance of research. An opportunity can be given the relatively small portion of the undergraduates who are specially

interested in and able to do research work by making thesis elective with the consent of the faculty, and by giving this consent only in cases where this special interest and ability has been pretty definitely demonstrated.

In graduate schools the situation is quite different. Most engineers whose formal education ends when they receive their bachelor's degrees do not go into work where their major duties have to do with research. More training than can be given in the four-year curriculum is desirable for this type of work. As a result most men who go intensively and primarily into research are recruited from the graduate schools. It is quite fitting and proper that here more complete and detailed training in research is given, and that the carrying out of a specific research problem is one of the requirements for the degree. And this work should be supervised by men whose major interest and major ability lie in the direction of research.

It seems to be very generally agreed that one of the important functions of a first grade college of engineering is the promotion and carrying on of research. Most good colleges of engineering are relatively well-equipped for such work and have men on their staffs who have done and are doing work of this kind. Such work, and the higher forms of consulting service which often grow out of it, should doubtless be considered as normal forms of activity supplementing teaching service. Opportunities of this kind will attract able men to an institution as nothing else will do. But it must be realized that research ability and teaching ability are not always found together. A man's major interest cannot lie in two directions at the same time. He cannot be primarily interested in research and also in teaching. It is extremely difficult to jump from the laboratory where one is absorbingly engrossed in some research to the classroom and there do justice to one's teaching duties. A man may be a fine teacher if he devotes his major time and effort to teaching, or a fine researcher if he concentrates in that direction, but the chances are that he will not be much of a success at either if he attempts to divide his interest anywhere near equally between the two. Also, a man who is a notably good teacher may not have the characteristics which make for success in research, and a man who is outstanding in the research field may be a miserable failure as a teacher. In fact, the successful research man is very apt to be a poor teacher. His research interests are usually along some very highly specialized line that is in a very narrow band of some branch of knowledge. If he is teaching undergraduate work, he should cover, in any course, a much broader field than is included in his specialized line of investigation. He is apt therefore to have a very distorted viewpoint, to be lopsided in his teaching, and to

place undue emphasis and devote a disproportionate amount of time on the part of the field where his own interest predominates, at the sacrifice of other equally important parts. Also, fine research men have often been found woefully lacking in the ability to "put their subjects across" to their students.

The writer well remembers a time, a good many years ago, when he was in a position where he was supposed to do experimental and research work exclusively. But someone in authority at that institution had the idea that the inspiration that comes from research work should be passed on to the student, and so all research men were required to do a limited amount of teaching. In my own case this was one two-hour course. That course, as far as I was concerned, was an unmitigated nuisance. I remember very clearly that it always seemed to catch me at a time when it was particularly difficult to leave the experimental part of the job and that I often forgot or put off the preparation for it until so late that this job of preparation was not well done. My impression is that, instead of the students being inspired, they were bored, and probably wondered how it happened that so uninteresting and poorly informed an individual should be selected for a research job. I wonder if my own case is not rather typical in similar situations. It must be a great source of irritation to any man who is intensely engrossed in what seems to him to be an absorbingly interesting and exceedingly important research project to be forced to interrupt this work, which forms his major interest, in order to prepare for and teach a class. Unless he is an unusually conscientious individual the teaching work will be neglected and the poor undergraduate will suffer. No, it certainly is not conducive to good teaching to force men whose major duties and interests are research also to do undergraduate instructional work.

On the other hand, it is probably true that a man cannot be a good engineering teacher unless he has a keen appreciation of the importance of research, and a knowledge of some of the research accomplishments and activities in his own field. Perhaps an opinion of this kind accounts for the fact that in so many cases the advancement of the teaching staff is based largely upon proved research ability rather than upon teaching ability. In at least one university the administration, to my own personal knowledge, let it be known that no member of the undergraduate teaching staff need expect an increase in rank or salary unless he had shown evidence of productive scholarship. He must do research and the results must be published. There did not seem to be a very critical analysis of the work, but there must be something printed. Interest or ability in teaching seemed to receive no attention, but if a man could point to a paper presented before some organization, to an

experiment station bulletin, or something of that kind, his chances for an increase in rank and salary were good. And yet the formally-assigned duties of most of these men were entirely teaching. The researches had to be done on top of full teaching loads and at the initiative of each individual himself. Under such influences it certainly took a man of strong character to keep from slighting his teaching. In order to find time for the research activities the tendency was to spend as little time as possible in the preparation of classroom material and the study of the best way to present it, in the correcting of student exercises, in the attendance at faculty or other meetings where problems having to do with teaching are discussed, or in any other of the many duties related to teaching and the students. My own opinion is that this policy resulted in much poor research and much poor teaching, in much injustice to conscientious and competent instructors who continued to put their hearts and efforts into their undergraduate teaching without receiving any kind of recognition, in some advancements to men who did not deserve them, and in injustice to the poor undergraduates who were trying to learn something about the fundamentals of engineering and were being taught by men who were being tempted not to put their interests and efforts on the job of instructing these students.

Such an administrative policy may be wise from a purely advertising point of view. It may even result in increased financial support for a time, for it is easy to call attention to impressive lists of publications with high-sounding titles as being an indication of the high level of productive scholarship, especially if those who are to be impressed are unable to read the publications understandingly. But such policies certainly do not tend to produce good teachers and should therefore not be considered as defensible if the major function of an institution is to train undergraduate students. Would it not be far better to recognize and utilize, insofar as possible, real research ability where it is found and to make the most of real teaching ability without hampering it by enforced research activities when an individual is found who possesses it. The instructor who is a real teacher, who can awaken interest and enthusiasm in the minds of the student, who can stimulate him to put forth his best efforts, and who has the ability and judgment to give just the needed amount and right kind of explanation of the more difficult phases of the subject to prevent discouragement, is all too rare; perhaps more rare than the successful research man. When found, he should be held, encouraged, and advanced as rapidly as circumstances will permit, without considering his research ability. For, after all, the major duty of most of our colleges of engineering is to teach undergraduate stu-

dents, and this statement is made with entire cognizance of the fact that the desire to develop graduate work is almost universal.

The situation as discussed above would seem to be a rather difficult one. As has been pointed out, it is considered very important to give even undergraduate students a keen appreciation of the importance of and wonderful opportunities connected with research. If that is to be done, the instructors of these students must be interested in and well informed concerning research. Yet if these instructors are selected on the basis of their research attainments, or after being selected, are influenced to spend a large part of their energy on research, then their major interest and ability will not be in the direction of teaching. As a result they are likely to fail to awaken and keep the interest and enthusiasm of the students, and to give proper attention to their purely teaching duties and problems. What is the answer? How can the proper balance between teaching and research be attained?

The writer, in attempting to answer this question, feels that the first thing that must be emphasized is that when an instructor is needed to teach undergraduate students he should be selected on the basis of his teaching, not research, ability and should be given to understand that he is expected to put his interest and effort in the direction of teaching and teaching problems. If he becomes interested in research, consulting, or any other line of work, it must be definitely understood that this other interest must not interfere with his duties to the undergraduate student, no matter how worthwhile his other interest may be, unless, of course, provision is made to relieve him of his usual responsibilities. Research interest should be encouraged and research ability should be developed, but not at the expense of the student. If an instructor becomes interested in a worth while research project it may be wise to lessen his teaching load, or even to relieve him altogether from teaching assignments for a period, if that can be arranged. After he has completed the particular research problem he may be willing to return to his teaching duties. If so, if he has real teaching interest and ability, he will probably be a more inspiring teacher than he was before. But it is important that while he has undergraduate teaching duties, research activities must not be allowed to interfere with them. Moreover, if an instructor proves to be the right kind of a teacher but does not take an interest in doing research himself, that fact should not be allowed to prevent his recognition and advancement as a teacher, and he should never be unduly influenced or coerced to attempt to carry on research.

Teaching ability is much less important and research ability relatively more important in a man engaged for graduate school work. Graduate students should be able to work more independ-

ently, they require less teaching, than undergraduate students, their work is much more highly specialized, and much of it is actual research. Therefore men needed to direct graduate work should probably be selected on the basis of their research attainments rather than on their teaching ability. There are of course many men who are expected to supervise both graduate and advanced undergraduate courses. Research ability is doubtless of great importance in them.

The combination of an engineering experiment station or a strong graduate school, or both, on the same campus with an undergraduate college of engineering is a happy one. At such an institution there are opportunities in the engineering experiment station for research professors who have outstanding ability in the direction of research, but may be poor teachers and unwilling to spend time and energy on teaching. In the graduate school, men who are outstanding in the research field but who in addition may be interested in student contacts and willing to spend some part of their time on teaching, will find opportunities. And the undergraduate college is the place where there is large need, and should be abundant opportunity, for the good engineering teacher who finds satisfaction and joy in dealing with the students, in studying their problems, and in doing an all-around first class teaching job. There will, of course, be a large amount of overlapping between the three different groups described above. It will not be possible to draw definite lines of demarcation between them. Also, there will be many friendships between the men in the different groups and these friends will have a large amount of interest in each other's problems. In such an environment the narrow research specialist will be broadened by contact with the able teacher and the teacher who may not have the time, interest or ability to pursue high class research projects will be informed and perhaps inspired about research possibilities and attainments by men who are devoting their lives to such work. Thus, this teacher, who does not himself spend large amounts of time on research, but prefers to devote his entire energy to his teaching, will be enabled to pass on to the student an appreciation of the importance and place of research in engineering. It thus should be possible to attain the proper balance between teaching and research, and to realize the emphasis on research, so important in undergraduate engineering education, without sacrificing the teaching ability of the instructional staff.

## CIVIL ENGINEERING

By S. C. HOLLISTER, Cornell University

I take it that the subject of this session of the Society which also is the subject of this paper, is in the nature of a query, whether research is really an instrumentality in engineering education, or whether it is an adjunct to the normal educational procedure. On this premise, therefore, it appears to be necessary, first, to inquire into the real object of research, and then of engineering education, and thence to proceed with an examination into their possible correlation or interdependence, if indeed such exists.

Research signifies the process of hunting for new truths. It is to my mind a misfortune that "research" has in many places come to mean a certain busy-ness of testing the behavior of things, or of assumed laws, in fields where our knowledge of the behavior of such things or laws is at present reasonably complete. Obviously research is not measured in terms of dollars spent, but only in terms of the laws developed. On the other hand we must not confuse invention with research, but must recall that invention signifies the establishment of a new process or apparatus, whereas research deals with the first determination of the underlying laws. A considerable amount of so-called research activity is not strictly such. In the present discussion we will limit ourselves to research, omitting any discussion here of the value of either testing or invention and, in doing so, without inferring any judgment whatever as to the merits in educational work of either testing or invention.

We may find disputable a detailed statement of the objectives of education. Certainly, however, we should agree on four basic objectives to be accomplished in engineering education, namely, the development of a certain habit of mental approach; an acquisition of certain facts and laws; an horizon by which may be acquired a perspective for thought and judgment, not only as concerns engineering, but also as relates to life politically, socially and culturally; and lastly, an horizon by means of which is furnished an appreciation of the general nature and extent of the unexplored and unknown field of fact and laws, and the boundaries which separate it from known facts and behaviors. I take it that what an individual may do with such a training, having once acquired it, is an integration of this training with the individual's own inclinations, talents, environments and opportunities. In this light the educational procedure would be concerned with the establishment of the foundation for such accomplishments and not with the accomplishments themselves.

It is the hope of every engineering educator to instill into the students entrusted to him a certain habit of collecting facts and of

applying to them an analytical reasoning upon which may eventually be predicated a sound judgment. Where, in all of the work in the field of engineering, is this procedure more clearly found than in the work of research?

It is freely admitted by all, I believe, that the facts and laws upon which engineering procedure is based, are the results of some form of research, whether that research was by the more primitive trial-and-error method, or whether by the analytical reasoning that has distinguished the last two centuries from all that have gone before.

Certainly we may say that the establishment of an horizon in the technical field of the engineer's work is dependent upon our knowledge of facts and laws, and hence dependent upon the research accomplished at a given time.

Thus far in our inquiry we may conclude that the foundation of engineering education rests upon accomplished research. We have not as yet, however, established whether further research is needed, and if so, whether it has any relation to engineering education.

Let us now examine the major branches of civil engineering to determine whether the basic information in each is static and fully determined, or whether they are rapidly moving fields subject to future expansion or extension.

I believe it is fair to say that in the field of mechanics we have entered upon a new era. In the past decade we have seen rapid advancement in the application of the mechanics of fluids, of elastic bodies, and of plastic bodies, to important engineering problems. We have also witnessed noticeable advances in the study of dynamical effects upon engineering structures. Are we yet willing to say that we know all there is to know about the behavior of foundation materials, of subgrade materials for roads, of stress distribution in structural members subject in part to plastic deformation; of vibration effects on structures whether due to passing loads or earthquake oscillations; of the effect of wind on structures; of the stability of earthwork structures subject, among other things, to varying degrees of saturation? Are we satisfied with our present knowledge of river hydraulics? Has our general knowledge of fluid flow become complete as relates to spillway design, turbine and pump development, and the dynamical problems relating to them?

The sanitary engineer is the mainstay guardian of the public health. While it may be attested that a remarkable degree of protection has been afforded recent generations, when considered in the light of the pestilences of the ancient and middle ages, would any thoughtful engineer be willing to say that the equipment and

methods of the sanitary engineer of today are complete, and that there are no further problems facing him in the sanitary field the answers to which are not already known?

In the field of structural engineering there appear in varying degrees, many of the elements already itemized. To this may be added a need for extension of analyses to a number of important types of structures, the behaviors of which are not yet generally understood. Who may say that we know all there is to be known about existing structural materials, or that we have gone as far as we can in development of more suitable materials for the service conditions we must meet?

In transportation we have embarked on a new era. Highway transportation has opened many problems of design, and of the use of materials, the answers to which are being sought by active research in many organizations. Rail transportation appears to be entering upon a decided change of form, involving problems which are as yet only hazily indicated. Overlapping the several modes of transportation, is the need for their general coordination in the public interest.

And now we have come to what I believe to be the greatest problem that faces the engineering profession,—that is, the interrelation of the technical work of the engineer and the economic and social life of the community. The engineer is in part responsible for the recent change in economic and social condition. Certainly he has an important part to play in the solution of many of the problems relating to our social and economic structure. No man, whether an engineer or not, may honestly say that the solution of the engineer's part in our economic and social development is clearly defined and fully developed at the present time.

The field of civil engineering may then be said to be faced with vital problems on every front. This being so, we have in large measure a vital need for research on every front. But what relation has such research to our educational procedure?

In the first place, is it not fair to say that an appraisal of the nature and importance of these problems, taken together with our present developed knowledge, constitute an appraisal of the nature of engineering of the future? If this is true, should not such an appraisal be the guide to the development of our engineering curricula? Basicly, at least, our training of today must equip the engineer of fifteen and twenty years hence. To this extent, if to no other, the engineering educational institution must lead, rather than follow, the field.

In what other way can the educational institution develop the facts for the furtherance of engineering training than by research? To me there seems no other choice. Nor is there a better way in

which to train the engineer of the future in methods of attack upon the problems he certainly will be called upon to solve than by the training obtained in conducting research under competent guidance.

The very substance and methods making up our educational procedure, our engineering institutions must provide in an atmosphere made dynamic through persistent and continuous attack upon the problems facing the profession.

Although it is not feasible to engage the undergraduate student in research pursuit, it is important that he be surrounded with the dynamic atmosphere produced by a continuous research into the various fields in which he is receiving training, in order that he may be provided with the horizon so necessarily a part of his engineering training. The graduate student in engineering, upon whom more and more dependence will be placed for the solution of problems of an increasingly complex nature, must of necessity be given training, not only in research procedure, but in a broadened knowledge of the fundamental sciences for the purpose of enhancing his facility in researchful pursuit.

Engineering is a living thing. Research in engineering is its quickening pulse. Such research becomes not a thing apart, but must of necessity be the very warp and woof upon which the engineering educational structure is fabricated.

## CHEMICAL ENGINEERING

By E. E. RANDOLPH

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The modern trend in technical institutions is to consider educational work under three aspects: Class instruction, research, and extension service. Classroom instruction has always held primary consideration. Extension work in agriculture has consisted in publishing farm bulletins, in providing county agents, and in sending out demonstration agents and farm advisors. The extension work in engineering has been largely confined to the publication in recent years of the results of investigations in the form of bulletins issued by the various Engineering Experiment Stations and also to consultation work done by the individual professors. Many of the publicly supported technical institutions are more and more recognizing this three-fold duty and are now trying to an encouraging degree to contribute something definite for industry and business as the more progressive agricultural schools have contributed to better farming and stockraising. In the newer branches of engineering instruction, especially in chemical engineering, research is necessary as a definite basis of the instruction work.

As the Rocky Mountain and Pacific Ocean area is new compared with the age of the Appalachian System and frequently is subject to upheavals, so the ever-changing methods of chemical manufacture, synthetic development, and new processes frequently alter suddenly the economics of present procedure. However it may be in the older more stabilized engineering divisions, chemical engineering instruction cannot safely ignore intensive and as far as possible exhaustive research as a basis for study in its training men to fill responsible positions in progressive chemical industries.

The secretive practice of some industries, and particularly of some chemical industries, of guarding jealously their improvements in machinery and processes might seem to indicate that industry might not appreciate investigation and the publication of college research. But as a rule this is not the case. Indeed many important industries encourage graduate research by liberal contributions. Some even provide industrial fellowships in good colleges rather than maintain their own private research and development departments. The resulting benefits to the companies may outweigh the advantages of having their own private research departments: First, Deserving young men are thus enabled to do graduate work of a standard quality; Second, In a small industry it is less expensive to have the problems worked out in this coöperative way than to maintain a research staff and an up-to-date research laboratory; Third, The company in this way gains without extra cost the benefit of the counsel and experience of the teaching staff of the department concerned, and of the full facilities of the instructional equipment.

An extension of this idea of mutual helpfulness is the cooperative plan of engineering education Three or more plans of coöperation are in practice either of a research nature or in a degree have some of the equivalent values of research educationally:

1. In the Cincinnati plan the student is simply an operating man, regularly employed in an industry for part of the school year. He receives regular pay for his work and thus passes through his apprenticeship before graduation. His work is not necessarily usually research as such, but he does gain definite benefits equivalent to research advantages by following in his work a syllabus provided by the department.

2. In the Massachusetts Institute plan the company pays the salary of an Institute staff teacher, who is an expert in the work of the company, and also provides research facilities. The students in this Practice School receive no pay for their services. They are really in school in a very practical way and receive full scho-

lastic credit for their work. Here we have research in chemical engineering instruction actually at work. Small groups of not over 12 advanced students constitute the practice class. Their job is to gather actual data on any important operating problem, and to find the most economical and efficient solution for the actual plant problem. The benefits to the company are that at comparatively little expense it has the services of an expert with a corps of energetic, youthful, and enthusiastic helpers to gather facts and together work out the major plant problems. This work is wholly research.

3. Some institutions try to obtain part of the benefits of the coöperative plan for their students by attempting to find summer employment for them in the industries. Some companies still generously aid in this plan, although they can expect little return from such temporary help other than to try out prospective future employees. No organized research is attempted in this plan, although the wide-awake student receives equivalent benefits.

In the larger chemical industries it is practically a universal rule to maintain their own research and development divisions in addition to the routine plant control laboratories. In the research and development division all major plant equipment and process problems are investigated. The functions of this division are varied including such matters as developing new products, synthetic products, water treatment, processing difficulties, economics in operation, recovery of chemicals, utilization of waste products, exploiting by-products, improving the quality and saleability of principal products, increasing efficiencies, increasing the yield, of higher quality at minimum cost and in finding new and better ways of doing the work of the industry. A chemical engineering department is certainly neglecting an opportunity if it does not recognize such facts in the fundamental training of its students.

To be sure industries seek to protect their interests by securing patents on particular discoveries and inventions of their staffs, but still many of them are generous with their research information. An illustration of this spirit of coöperation with the progressive spirit of the age is observed in the fact that in the program of the recent meeting of the American Institute of Chemical Engineers nine reports of researches of importance were contributed by the research staffs of large chemical industries, whereas only four were contributed by the different institutions.

It is true that most of the chemical engineering staffs in technical institutions are fully loaded with instructional duties so that there is not much time left for as much personal research as is desirable and much of what is done is necessarily confined to super-

vision of amateur graduate students. Such work has certain limitations. The teacher is engaged with many things. The graduate student has other class and practice work requirements. The work is frequently interrupted. The college year is nine months. The first month is consumed in getting started, making plans, improvising equipment, and in making a review of previous investigations. Thanksgiving holidays, Christmas vacation, Easter week intervene. The mandate of the graduate committee that all research work for the year must be completed, written in approved form, and delivered into their hands attested, signed, and sealed at least one month before the end of the academic year, must be respected. All of these things perhaps are as they should be, at least they are true to form. If there were no problems to meet and solve there would be no justification for a chemical engineer. His job is to meet difficult problems. Hence to work under difficulties seems to be a natural background for his professional experiences, and itself constitutes a bit of the research idea.

Notwithstanding all of these and other interruptions and limitations the successful teacher must incessantly continue his research efforts. He cannot allow himself and his work to become stale and stereotyped. Chemical engineering instruction as itself a distinct branch of engineering is comparatively young. The earliest attempts recorded of a chemical engineering curriculum was an outline of work of this character at Tulane University in 1894 and at Massachusetts Institute of Technology in 1895. Courses in this branch of engineering did not become regularly defined until about fifteen years ago. During and after the war the functions of this branch of engineering became clearly defined in the plan of the more progressive technical institutions, and has become recognized as one of the major branches of engineering education. The enormous growth of chemical industries in this country, producing 19.3 per cent of the value of all manufacturing industries, has compelled the institutions to recognize the difference between a chemist and a chemical engineer. Even today we have some colleges giving simply chemistry instruction and calling it chemical engineering. Others give a collection of chemistry courses and certain engineering courses and any other convenient courses and call it chemical engineering. It is evident therefore that, because of the very newness of real chemical engineering curricula in technical institutions, because of the many phases of the chemical engineer's work, and because of the importance of chemical products to modern civilization and the rapidly changing processes and new developments, many fundamental problems have not yet been solved, and that it is a proper function of chemical engineering training to develop the research idea in the students.

When we consider that civil engineering as an applied science goes back at least to the time of Euclid and that mathematics goes further back to much older times and that there are some who still think that even these ancient forms of engineering are not closed books unsusceptible to research, much more must we realize the need of fundamental research in such a relatively new branch of engineering as chemical engineering. From the very comprehensiveness of the chemical engineer's work the research idea cannot be separated from his proper training, and the more successfully the student has been trained to recognize a processing problem, to analyze quickly and accurately a manufacturing situation, and find a practical method of handling it, the more valuable his training has been.

We should not overlook the fact that chemical engineers require especial training because of the large number of people working in typical chemical industries, the imminent dangers at all times, the exact control necessary, the nice adjustment of equipment, processes, and conditions, the large amounts of money involved in plants and machinery and the exact requirements of the products. The chemical engineer is first of all an operating and production man out in the plant, a control man, as well as later a research and development man. He must be able not simply to analyze the product to see if it is what he desired to make, but rather he must control conditions in each step of the process to assure a product of the desired quality, quantity, and cost. He must determine the proper location for the plant with reference to water supply, availability of raw materials, transportation facilities, markets, climatic conditions, type of building needed, proper materials for the construction of the building, machines, conveyors, and other equipment, the plant layout, accurate control of each unit, comparison of one process with another, input against output, cost against receipts, find and face sources of loss and waste, improvement of methods, and proper safety devices.

Dr. Arthur D. Little has said "Science is now advancing at a rate so rapid and with results of such far-reaching influence that no industry can hope to ignore research and live." If this is true of the industry, of how much more importance is it necessary for chemical engineering departments to read the signs of the times and to prepare men to cope with the requirements of the age of synthetic camphor, synthetic rubber, synthetic varnish, and synthetic nitrates.

## BRIDGING THE GAP BETWEEN UNIVERSITY AND INDUSTRY IN INDUSTRIAL RESEARCH

By MAURICE HOLLAND

Director, Division of Engineering and Industrial Research, National Research Council

When Professor C. F. Harding, Chairman of the Committee on Engineering Research, requested me to give an address at the Society convention at Ithaca I accepted the invitation without hesitation. Professor Harding suggested that I bring the Society up to date with observations on the significant trends in coöperation between industries and universities in industrial research since my address at Corvallis two years ago. In connection with my duties as Director of the Division of Engineering and Industrial Research I am frequently in contact with industrial research executives in a wide range of industries and have heard them on occasion express very definite views as to how the gap could be closed, how the relationship could be strengthened, and what are the practical obstacles in establishing closer coöperation. At the time it appeared to me there was unanimity of opinion among directors of research, that their views had become crystallized into very definite views which might serve as a basis of recommendation and provide the starting point for mutual interest.

I was mistaken. I learned that the problem was highly controversial, the views expressed highly individual, the means suggested very diverse, the analysis of the underlying problems reflected the viewpoint of the requirements of specific industries, differences in geographic location, and established relations with certain universities. I then determined to do a bit of investigation and present a factual analysis of the data obtained. I requested the deans of a number of representative engineering schools to give me their views as to the practical problems which stood in the way of closer coöperation between the universities and industries in research. I summarized the results of this investigation and prepared a statement which was sent to a dozen or more research executives who had more or less wide experience in the practical operating problems of coöperation with university research laboratories.

Although my original request for information and data from research executives was started in what I thought to be ample time before my appearance at the convention, I was chagrined to learn as the day approached for my address, the data which I had before me at the time seemed to be highly controversial, irritatingly confusing and not sufficiently representative, for presentation by an officer of the Research Council before such an important and representative group of university officials.

On a plea of inability to present the subject adequately I was permitted to continue my investigation and present the data in the form of an article for your JOURNAL.

I trust that the information and data presented herewith will serve its original purpose and may serve as a guide to the future development of improved methods and techniques for the cooperation between universities and industrial research organizations.

In presenting these data I supply the facts as submitted to me by what I consider a representative number of experienced research executives without prejudice or without an attempt of interpretation for specific purposes.

*F. W. Nitardy, Vice President in charge of research of E. R. Squibb and Sons,* opens his statement with a complementary remark for the high regard in which he holds university talent and indicates that his experience has demonstrated that industrial research programs in universities are intelligently conducted.

Mr. Nitardy believes that "industry should be informed by university progress reports of their current research work; publication of university research should not be restricted to private publication. If industry was posted on university research activities it would stimulate their interest and in that way industry's problems would be brought to the university. Mutual interest would be stimulated if industrial research representatives were invited to scientific, technical, and engineering society meetings." Mr. Nitardy believes that these meetings should not be restricted to their own membership.

On the subject of competition, Mr. Nitardy brings up the old question of the difficulty in discussing publicly the specific research problems of an individual company. He adds, "If industry tries to produce something advantageous over its competitors, thus too early discussion of results proves a commercial disadvantage. Privacy on certain problems must be dealt with by industry and by private coöperation between the university and the interested industrial company. Coöperative research by universities of immediate benefit to industry, Mr. Nitardy agrees, will result in industry supporting more fundamental university research. One handicap in the coöperation between universities and industries mentioned by Mr. Nitardy in his statement is that the universities do not have sufficient funds to send their research men to industrial plants in the special field of their research interest to become familiar with their current problems. If some practical means could be developed to make this possible, Mr. Nitardy believes this is a most promising lead. As a specific recommendation

Mr. Nitardy concludes with this statement: "If industry knew that a certain university was working on problems of interest to that particular industry they would gladly finance a visit to their plant of the university research director or some member of his staff for an exchange of information and consider it a worthwhile investment of their company." Mr. Nitardy is of the opinion that the drug industry as a whole has a keener appreciation of university research and that other industry should benefit from the results of research and its application to human welfare.

*Doctor L. M. Tolman, Director of Research, The Wilson Packing Company,* believes that the problem of coöperation between universities and industry in research is primarily a problem of personality. As Doctor Tolman views it, industry wants immediate results. It should not pay for fundamental research normally carried on with university funds. On the other hand, according to his views, the university tackles problems of a fundamental character, many of which are endowed by fellowships and thus should not be interfered with to get immediate results since the purpose is the training of research men.

Doctor Tolman believes that in general the two types of research problems should be handled differently: First, definite physical and chemical problems tackled for immediate results should be done in industry; second, broader theoretical problems should be financed for a long term period and carried out in universities. The old stumbling block of the publication of research as one factor in university research coöperation is raised by Doctor Tolman in the statement that "industry wants to keep the results of research secret for a long time; universities want to publish the results of fundamental investigations at once."

*Mr. E. D. Milener, Director of Research of the American Gas Association* contributed an excellent statement on his views of the practical problems in establishing closer relationship in university and industrial research. As most of the material contained in Mr. Milener's statement was presented as an individual paper at the annual convention I will refer you to the original source of that data rather than comment on it here. The American Gas Association is, however, one of the most research minded trade associations dealing in coöperative research and extensively using all types of research agencies open to such associations. Mr. Milener's views based on extensive experience with the practical operating problems of a research executive equipped with a laboratory of his own and yet recognizing the benefits of cross-fertilization through coöperation with other agencies has touched upon

most of the important factors developed by statements received from a representative group of research executives.

*Mr. Norman F. Kennedy, Research Director of Corn Industries Research Foundation* is in the somewhat unique position of not operating a research organization as an integral part of the Foundation but serves as a clearing house for research information and directs fellowships at a number of universities for determining the nutritional value of food products of the corn industries.

The activities of university-industry coöperation appear to Mr. Kennedy to be "unsurmountable under existing conditions." Successful companies, Mr. Kennedy contends, "due to secret activity in research will not coöperate fully with universities." Universities by the creation of foundations to which patents are turned over and through which royalties are exacted from industry, have been at least one contributing factor in reducing the volume of research turned over to universities in the industries with which Mr. Kennedy is in contact. Mr. Kennedy believes that the personality of the department head of university research is an important factor. In some cases the tendency is to distrust industry and the university man has little appreciation of the commercial application and economic values of the results of research. On the other hand, the industrial executive, as Mr. Kennedy sees him, has little or no conception of the real value of scientific work. The research worker himself does not always understand the economic aspect of the company's viewpoint. Director Kennedy has found university research work of considerable value in specific instances. His definite recommendation, somewhat similar to that of Mr. Nitardy's of Squibb and Company, is that the member companies of his association industries would welcome university research men in a visit to their plants. These actual visits of the interested research personnel would serve as the basis for better understanding by industrial executives of university research services and staff and the university research representatives would have an opportunity to study on the ground under practical operating conditions the technical and the *economic* conditions of a specific industry.

Other research executives who submitted statements, orally or in writing, but who preferred not to be quoted enumerated as specific factors which are hindering the development of closer relationship between the universities and industries in this order of importance and with this frequency in the majority of instances:

(1) *The Patent Situation*—An equitable distribution between the university and the sponsoring company of the rights to a patentable discovery in science of research;

(2) *Publication of Results*—The competitive advantage of at least six months lead in the commercial exploitation of a newly developed product seems essential to industrial research executives;

(3) *Delays and Lack of Immediate Results in University Research*—University research staffs seem unable adequately to demonstrate progress during the earlier stages of fundamental research which will satisfy impatient executives who are under pressure for immediate results;

(4) Placing of university research projects on a tentative basis to locate experienced research personnel and transplant them to the seclusion of a private industrial research laboratory;

(5) The lack of frequent contact, particularly of university research personnel with the practical operating conditions and *values* under which industrial research laboratories must operate.

In conclusion it would appear that at least two significant and specific problems have been raised to which university research officials should give their attention. First, is the more or less uniform policy with regard to patents and the proprietary rights to the results of the discoveries of science and research in universities. In order that industry will receive uniform treatment under standardized practice with regard to the patent rights resulting from coöperative university research. Second, some means might be developed for bringing together the directors of university research agencies with industrial research executives at annual conferences, or more often, which would result in the invitation of university research workers to visit industrial plants and become better acquainted with operating conditions and personnel.

Under the Chairmanship of Dean Barker of Columbia University, the National Research Council has a committee which is attempting to evaluate the research facilities and capacities of the engineering schools and universities of the country as a first step in any constructive program which may be developed under the joint auspices of the Society for the Promotion of Engineering Education and the National Research Council or other interested organizations.

## COLLEGE NOTES

**University of Alabama.**—The College of Engineering opened the year 1935–36 with an increased enrollment over 1934–35. In order to adequately take care of the student body new instructors and new equipment were added to the existing facilities. Dr. Kenneth W. Coons, who did his undergraduate work at the University of Alabama and received his doctorate at Columbia University, was made Instructor in Chemical Engineering. Dr. Coons was formerly research chemist with the National Aniline and Chemical Company, Buffalo, N. Y. Mr. J. W. MacKay, B.S. in Aeronautical Engineering, was made Instructor in Surveying and Mechanical Drawing. Mr. M. A. Thomas, M.A., University of North Carolina, was given charge of all classes in English in the College of Engineering. Professor Oscar Dahlene, M.S., University of Kansas, was made head of the Department of Mechanics.

**University of Arizona.**—The College of Mines and Engineering has opened with an increase of nearly 20 per cent over the same period last year, which is probably the largest increase in a single year in the history of the institution. The largest increase has been in mining engineering and reflects the fact that the demand for mining graduates is much greater than the supply.

The first two of the seven new buildings to be erected on the campus of the University this winter are about half completed, and it is expected that one other building will be begun before the first of November and that the rest will be under construction by the first of the year.

The only changes in the faculty of the College are in the nature of additions. Dr. F. W. Galbraith (Harvard and Arizona) has been appointed instructor in Geology, and Mr. A. J. Thompson (Arizona) now holds an instructorship in Metallurgy.

Mr. Frank C. Brophy of Phoenix has presented to the College of Mines and Engineering the mineral collection accumulated by his mother, Mrs. Ellen E. Brophy. It comprises between 1,500 and 2,000 specimens and includes much magnificent material obtained from Arizona mining properties in the early days when they were working in the oxidized zone. The College already owns the finest mineral collection in the Southwest and this donation will improve the quality of the material exhibited. The specimens that are not needed in the College collection will be placed in the Arizona State Museum collection on the campus of the University.

**University of Arkansas.**—The new Library and Chemistry Building erected this year at a cost of approximately half a million dollars each, are in use this fall. They are built of cut limestone and Arkansas marble, in harmony with the Engineering and Agriculture Buildings erected in 1926, and further develop the general building plan of the University.

The Chemistry Building is three stories and gives commodious and convenient quarters with the most modern equipment.

The Library Building is also three stories and has a frontage of 178 feet. The three stories contain, in addition to all library service units, the Museum in the basement and the President's suite on the first floor. This floor contains also the two reserve rooms and the five seminar rooms; the second floor contains the main reading room and the recreational reading room, the library offices and work rooms. The seating capacity of the building is 610; the book capacity about 150,000 volumes.

**Armour Institute of Technology.**—Changes in faculty personnel:

Pearl, William A., B.S., M.S., Ph.D., has been appointed Associate Professor of Mechanical Engineering and Director of the Engineering Shops which were reopened this fall for students in Junior and Senior years of Mechanical and Electrical Engineering courses. Dr. Pearl is a graduate of the Washington State College, where he also received his Master's degree; his Ph.D. degree in mechanical engineering was received from the University of Michigan. He has had several years experience in industry,.and has taught at Washington State College and Benson Polytechnic Institute.

Potter, James G., B.S., M.S., has been appointed instructor in Mathematics. Mr. Potter received his Bachelor's degree from Princeton and his Master's degree from New York University. He has also studied and taught at Massachusetts Institute of Technology and taught at Yale and New York University, and he has had some commercial experience.

Goetz, Billy E., B.S., M.S., has been appointed Instructor in Economics. Mr. Goetz studied at the University of Chicago and Cornell University, and has taught at the Universities of Buffalo and Chicago, besides doing commercial work for James O. McKinsey Company.

Snediker, Harvey O., B.S. has been appointed Assistant Professor of Fire Insurance. Mr. Snediker graduated from Armour Institute of Technology in 1928, since which time he has been with the General Inspection Bureau at Minneapolis and the Western Actuarial Bureau at Chicago.

Olson, Elder J., B.S., M.S., has been appointed Instructor in English. Mr. Olson is a graduate of The University of Chicago, and has won many prizes in literature and is a well known writer.

**Bucknell University.**—In common with most schools, Bucknell has a substantial increase in the total enrollment for the present school year. The largest freshman class in the history of the institution as well as the largest number of upper class transfers have been added to the student body this year. There has been an increase in the general student body of the university of twenty-five per cent, while the increase in the number of engineering students is forty per cent over that of last year. An additional increase for next year is anticipated due primarily to the large number of transfer students from the Bucknell University Junior College at Wilkesbarre, Pennsylvania.

The department of chemical engineering has added two important pieces of equipment to its chemical engineering laboratory during the last summer. A ten-foot pyrex glass gas absorption tower has been installed. It is nine inches in diameter and is filled with pyrex glass rings. The visual inspection during the study of the solution of gases in liquids as well as the stripping of gas from liquid streams will facilitate such studies. A fifty gallon copper distillation unit including a thirteen-foot fractionating column, dephlegmator, condenser and receivers has also been installed in this laboratory. The column is eleven inches in diameter and the overall dimensions of the equipment are approximately twenty-five feet. A new laboratory has been provided to house this equipment for the study of semi-plant problems in this field.

Professor W. G. Owens retired in June after fifty-five years of service with the university, the last fifty of which were spent in the department of chemistry. He was professor of chemistry and director of the chemical laboratory. Due to the sudden death of Professor O. S. Groner, also of the chemistry department, Doctor R. R. Legault, who has been appointed a member of the faculty of this department, assumed responsibility for the courses in Quantitative Analysis, Organic Chemistry, and Physical Chemistry.

Doctor George A. Irland of the department of electrical engineering has been engaged during the summer with the United States Bureau of Mines in a study of the use of portable seismometers for the determination of vibrations accompanying mine explosions. The electrical engineering department has recently added a fifteen hundred watt distribution transformer and a five kilovoltampere, three phase, wound rotor induction motor. This equipment is of the most modern design and will facilitate experimental study for undergraduate students in this department.

Dr. Carl Frederick Prutton, Associate Professor of Chemical Engineering at the **Case School of Applied Science** has been made full Professor of Chemical Engineering and new head of the department, succeeding Dr. William R. Veazey, who resigned recently to take an executive position with the Dow Chemical Company. Professor Prutton is widely known for his work on solvenized gasoline and for much beneficial research in the studies of paints and varnish. Dr. Prutton is a graduate of Case in the class of 1920. Since that year he has been a member of the faculty. His degree of Doctor of Philosophy was obtained from Western Reserve University.

The Faculty Council has approved the establishment of a Board of Freshman Counsellors, headed by Professor L. W. Mills, assistant to the dean. Other members include: Dr. R. J. Altpeter, Chemistry Department; Professor O. M. Stone, Engineering Drawing Department; Professor E. M. Justin, Mathematics; Dr. G. W. Sanford, Social Studies, and Mr. R. L. Shurter, Language and Literature. As explained by the president, Dr. W. E. Wickenden, "the initial purpose of the board is to be of direct assistance to freshmen who are having difficulty with any of the first year courses. The purpose is to catch difficulties in the incipient stage and to deal with them informally, before they are reflected in the reports or call for action by the dean."

**The Catholic University of America.**—An Aeronautical Engineering building has been completed and equipped for use during the present school year. It contains a three-foot and a six-foot wind tunnel for velocities up to 200 miles per hour. It has a special library, drafting room, and fabrication shop. Two new men were added to the staff, Mr. Kermit Parker and Mr. William Taylor, who are to serve as laboratory assistants, fabrication and model-making instructors, and test pilots.

Professor George Weschler, Head of the Department of Mechanical Engineering, is taking one year's leave.

**Clemson College.**—The Engineering School started off this fall with the largest freshman enrollment in its history. There are 216 engineering freshmen with a total of 646 first year students in the College. The college enrollment is 1515 which is the largest the institution has ever had. The increased enrollment has made more living accommodations for students necessary and a new barracks with 200 rooms is just being started. A temporary wooden structure to house 150 students has been put in service. At the same time a new agricultural building, which the college needed badly, is in progress. In connection with the new buildings an enlarge-

ment to the heating plant is necessary. An integral boiler to use powdered fuel is being installed. It and other additions and changes are planned with an idea to being of use in the teaching of mechanical engineering students. $800,000 has been allotted to the two buildings and the necessary works in connection with them.

Professor J. H. Sams has remained on leave of absence at the University of Michigan where he is Assistant Professor of Mechanical Engineering and is pursuing work to a doctorate.

For the second year, Professor C. H. Topping is carrying on Professor Sams' work in his absence.

Dean S. B. Earle has recently been made Chairman of the Greenville Section of the American Society of Mechanical Engineers.

The Southeastern Regional division of the Student Branch of the American Institute of Electrical Engineers will hold its annual meeting at Clemson College during the coming spring.

**University of Colorado.**—This year the College of Engineering, with other divisions of the University, is using the literal system of grading, which was adopted last year and first put into effect at the close of the winter quarter.

New members added to the staff this year are Arthur J. McNair, instructor in Civil Engineering and Fred Cooper, instructor in Electrical Engineering. A. G. Oberg, instructor in Chemical Engineering for the fall quarter, is taking the place of Dr. Odon Knight, who is on leave of absence; and William F. Dowling, instructor in Chemical Engineering for the year, is taking the place of L. G. Latronico, on leave of absence.

Professor Fred R. Dungan, after seventeen years as a member of the Department of Civil Engineering, retired last June.

Professor M. S. Coover, member of the Department of Electrical Engineering since 1919, resigned last summer to become head of the Department of Electrical Engineering at Iowa State College, Ames, Iowa.

**Cornell University.**—The only faculty change of importance was the appointment of Professor H. T. Jenkins as Professor of Drawing in the School of Civil Engineering. Mr. Jenkins was formerly at the University of Michigan.

For the past few years the number of freshmen entering the University has stood practically stationary. This year, however, there is a little increase in numbers.

The will of the late John McMullen of Norwalk, Conn. provided for the establishment and maintenance of scholarships in engineering at Cornell University. At present the funds from this source support 200 scholarships of $200 each. Until this year these scho-

larships have been conferred on students in residence partly on the basis of scholarship and partly on the basis of need. Last year the method of award was extended to include prospective students. And this year 15 Regional scholarships of $200 each were established. The recipients are selected primarily on their scholarship record in the preparatory schools. The first fifteen scholarship holders on this basis entered the University this fall. It is hoped as funds accrue to increase the value of these scholarships.

**University of Delaware.**—The Freshman Class in the School of Engineering experienced a substantial increase in enrollment this year of 28 per cent.

Thomas D. Mylrea has been increased in academic rank to Head of the Division of Civil Engineering.

Delaware is starting a substantial program of tests of bar reinforced concrete slabs under the auspices of the Rail Steel Bar Association and the Concrete Reinforcing Steel Institute. The program, which at present is designed to cover approximately two years of work, will be equally divided between Delaware and Lehigh University.

During the past month we have received as a gift two 300 HP. Marine type Diesel engines, 12 cylinder, $5 \times 7$, value $34,000.00.

**University of Detroit.**—Weekly assembly periods in the College of Engineering are being made into a regular extra-curricular instrument for broad education. The charge is frequently made, with some justice, that engineers as a group tend to be narrow and ignorant in fields other than their own. The engineering profession, employers of engineers and engineering educators insistently demand that action be taken to correct this deficiency. Correction is not easy because the greater portion of the curriculum must of necessity be devoted to scientific and technical subjects. It is impossible to give engineering students a thorough liberal education, although the faculty has included as many general and cultural courses as possible.

An effort is now being made to make the assembly an additional means for overcoming the difficulty. Speakers from fields other than engineering will address the students during the year. Except for the monthly coördination assemblies, conducted for cooperative students, strictly engineering type assemblies will be limited. Attendance is compulsory and a strict check is made of those present. Some of the subjects of broad cultural interest to be covered in these assemblies include:

The Meaning of Citizenship
Human Development
The City Government and Its Functions
The Housing Problem and the Engineer
Personality
Insurance In Modern Life

Most of the speakers are obtained from outside of the University, although in one instance, the Department of Biology of the College of Arts and Science has supplied a speaker.

**Ecole Polytechnique.**—Starting on December 1st, Mr. Augustin Frigon, present Dean, will become President of the Corporation de l'Ecole Polytechnique. Mr. Adhémar Mailhiot, Professor of Mineralogy and Geology, is promoted to the position of Dean with Mr. Armand Circé as Assistant Dean. Mr. Aurélien Boyer has been named Honorary President of the Corporation de l'Ecole Polytechnique.

**The George Washington University.**—Mr. Reinier Beeuwkes, Jr., was added to the staff of the School of Engineering as an Instructor in Civil Engineering, teaching Engineering Mechanics. Mr. Beeuwkes is a graduate of the University of Washington and has studied under Professor Jacob Pieter Den Hartog of Harvard University.

**University of Hawaii.**—Mr. R. C. Brinker, B.S. Lafayette College, M.S. University of Minnesota, formerly instructor in Civil Engineering at the University of Minnesota, has joined the staff as Instructor of Engineering.

Professor E. C. Webster, Professor of Mathematics, has been appointed Dean of Men.

Mr. W. R. McAllep, Lecturer in Sugar Technology, is in charge of the general chemistry course for the first semester, taking the place of Dr. Earl Bilger who is absent on leave and studying in England.

Professor J. M. Young has completed the structural steel design for the proposed new auditorium which, when completed, will have a seating capacity of three thousand.

**University of Idaho.**—The enrollment of the College of Engineering shows some signs of returning to normal in that the enrollment this fall is 6.6 per cent below that of a year ago. However, it is still 18.5 per cent above that of the fall of 1933 when the enrollment was about average.

A new Engineering Drawing building of a temporary nature was built this past summer to relieve the crowded conditions caused by the increased enrollment of the past two years. This building is one of the three erected this summer by the University. Although these are only frame buildings, they are well constructed, attractive in design, and adequate to meet the emergency.

During the past year and a half, the Civil Engineering and Electrical Engineering laboratories have been completely remodeled and enlarged to handle larger classes.

Mr. Arthur J. Davidson has been added to the Engineering faculty as an instructor in Civil Engineering.

**Iowa State College.**—*Agricultural Engineering:* Professor J. B. Davidson, head of the department, is attending the Second International Congress of Rural Engineering in Madrid, Spain. Ira W. Dickerson, B.S., University of Illinois, is acting associate professor for E. G. McKibben who is a research fellow working for his doctor's degree at Iowa State College. Frank B. Lanham, B.S., Virginia Polytechnic Institute, and Albert J. Sailer, B.S., Iowa State College, are new research fellows.

*Chemical Engineering:* Dr. E. L. McMillen of the University of Minnesota is assistant professor. He succeeds Dr. F. C. Vilbrandt who has gone to the Virginia Polytechnic Institute as head of chemical engineering. Richard E. Benson, B.S., University of Arkansas, and Grover L. Bridger, M.A., Rice Institute, are new graduate assistants.

*Civil Engineering:* John A. Logan, M.S. Harvard University, is a new instructor in the department.

*Electrical Engineering:* M. S. Coover, formerly professor of electrical engineering at the University of Colorado, is now head of the department at Iowa State College. He succeeds F. E. Johnson who became Dean of Engineering at the University of Missouri.

*Engineering Drawing:* O. A. Olson, who taught drawing in our mechanical engineering department, has been appointed associate professor and acting head of the newly organized department of engineering drawing. H. J. Berkel, B.S. and M.S., Michigan State College, is a new instructor. Members of architectural, civil, and mechanical engineering staffs are assisting in the new department.

*Engineering Personnel:* L. O. Stewart, formerly associate professor of civil engineering, is now Engineering Personnel Officer. He succeeds Professor F. D. Paine, who continues as head of general engineering and is giving a large amount of time to the development of rural electrification projects in Iowa.

*Engineering Experiment Station:* W. C. Dachtler, B.S., Iowa State College, Wilbur E. Hitchcock, B. S., University of Wyoming,

James A. Johnston, B.S., Texas A. & A. College, Thomas Robert McElhinney, B.S., Iowa State College, and Robert L. Tillson, B.S., Iowa State College, are new assistants on the Experiment Station staff, the latter two in cooperation with the U. S. Department of Agriculture.

*Mechanical Engineering:* M. P. Cleghorn, Professor of Mechanical Engineering, has been appointed Professor in charge. He succeeds N. P. Bailey who is now head of mechanical engineering at Rutgers University. Dr. H. P. Nielson comes from the University of New Mexico to take the position of assistant professor.

*Theoretical and Applied Mechanics:* George Pagels, who has been with the Engineering Experiment Station, is now an instructor in this department.

**The State University of Iowa.**—Our former Dean, C. C. Williams, was called to Lehigh University as its President, and was inaugurated on October 1. Bryon J. Lambert has been appointed Acting Dean of the College of Engineering.

The following men have been added to our faculty:

Mr. E. W. Lane, Purdue, 1912; Cornell University, 1914; as Professor of Hydraulics in the Department of Mechanics and Hydraulics. Professor Lane comes to us directly from Denver, where he has been Research Engineer with the U. S. Bureau of Reclamation on Boulder Dam, Grand Coulee Dam, All American Irrigation Canal, Norris and Wheeler Dams, etc. At various times in his career, he has been with the Morgan Engineering Co; the construction of Air Service Camps during the War; in China as Manager for Morgan Engineering Co.; St. Lawrence Waterway Board; Mississippi River Spillway Board; U. S. Rivers and Harbors Board; U. S. Engineers Corps; etc.

Mr. J. M. Russ, as Assistant Professor of Engineering Drawing. Professor Russ is a M.S. from Ohio State University. He has had considerable active practice with various firms, and for some 12 years has been Assistant Professor and Associate Professor of Engineering Drawing in Ohio State University. He has also been exchange Professor from Ohio State with Purdue University and also with Carnegie Institute of Technology. He assisted Professor Thomas French of Ohio State University in the revision of several editions of French's " Engineering Drawing " and other books.

Mr. O. J. Baldwin was transferred from the Department of Engineering Drawing to the Department of Civil Engineering where his work will be mainly in Surveying and Mechanics and Materials.

The increase in attendance this year is about 10 per cent over last year.

Enrollment at **Kansas State College** this fall is the largest in the history of the institution. On September 30 the figures showed a total enrollment of 3351 for the college, and increase of 630 above a year ago. For the Engineering Division the total enrollment was 871 for the same date, being an increase of 135, or 18.3 per cent, above that of the same date a year ago. The largest increase occurred in the junior year students.

A number of changes in the faculty have taken place. Mr. John C. Olsen, instructor in the Dept. of Machine Design, resigned to work with the John Deere Plow Co. at Waterloo, Iowa. His position is now filled by Mr. F. M. Adair who received his Master's degree in mechanical engineering in 1932 from Kansas State. In the same department Mr. J. L. Brubaker, M.S., Kansas State College, 1932, has been engaged to care for increased work in that department.

Assistant Professor H. W. Aiman, of the Shop Practice Department has been granted a year's leave of absence on account of ill health and his work has been taken over by Mr. L. A. Moore. '25, Kansas State College.

In the Agricultural Engineering Department, Assistant Professor C. A. Logan resigned to engage in soil erosion work for the federal government, and his place has been filled by June Roberts. Mr. J. L. Gale, a recent graduate of the University of California, has been engaged as Graduate Assistant in that department.

The Department of Applied Mechanics has two new men, Mr. T. G. Beckwith as graduate assistant and Mr. N. J. Sollenberger as fellow from a grant by the Dewey and Almy Chemical Company. Both are recent graduates of the college.

The Mechanical Engineering Department also has two new men, Mr. A. J. Churchill, temporary graduate assistant, '35 K. S. C., and Mr. David Gold, Graduate Research Assistant who comes from Purdue University.

In the Electrical Engineering Department an exchange of professors was arranged with the University of Pittsburgh. Professor R. W. Ahlquist, from Pittsburgh, will serve this year with Kansas State, while Professor O. D. Hunt, from K. S. C., is at the University of Pittsburgh. Mr. L. C. Aicher is another new man in the Electrical Engineering Department, serving as Graduate Research Assistant. Mr. Aicher will conduct research work in connection with wind-driven electric plants for farm homes.

**University of Kansas.**—D. C. Jackson, Jr., head of the Department of Electrical Engineering, has resigned to assume the presidency of Lewis Institute, of Chicago.

Robert Warner, professor of electrical engineering, is on leave

of absence for one year. He is an exchange professor at Massachusetts Institute of Technology. R. H. Frazier, Massachusetts Institute of Technology, is taking Professor Warner's place.

Edwin W. Hamlin, of Union College, Schenectady, has been appointed assistant professor of electrical engineering.

Theodore Marshall, from Case School of Applied Science, has been appointed assistant professor of mechanical engineering. This appointment is an addition to the present staff, made desirable by large enrollment.

Enrollment in the engineering school shows an increase of 17 per cent over that of last year.

Miss Gladys Swope takes the place as chemist in the water and sewage laboratory of the State Board of Health made vacant by the resignation of Selma Gottlieb Kallis.

**University of Louisville.**—The Speed Scientific School has been accredited by the American Institute of Chemical Engineers. The School is the first south of the Ohio River and the twenty-third in the nation to receive approval.

**Manhattan College.**—The progress of the School of Engineering has been marked by the establishment of an Electrical Engineering course leading to the degree of Bachelor of Electrical Engineering. The course is under the direction of Brother Bernard, F.S.C., E.E. Another forward step is seen in the increased enrollment in the School of Engineering. There is an increase of 16 per cent over last year's registration.

There has been a change in the Industrial Engineering Department, Mr. Julius Seidl, I.E., M.A., is the new Head. He has been practicing industrial engineering both in the United States and abroad and has been teaching for the past several years. Under his direction the students have launched out into a full program of inspection trips. Visiting lecturers are invited and plans are being made to meet other metropolitan student branches.

The Materials Laboratory has had several additions. Mr. Daniel J. O'Connell, C.E., M.S., in charge of this has added a Fatigue Machine by Baldwin and Soutwark. This will be used in the study of fatigue phenomena in ferrous and non-ferrous materials. A Riehle Impact machine with a moment arm of 110 and 220 foot-pounds and a 300,000 pound Soutwark-Baldwin universal testing machine make up the new additions. Mr. O'Connell has several other machines in mind which will probably be placed in use in the Laboratory before the next semester.

**Massachusetts Institute of Technology.**—First year students entering the school of Architecture at the Institute will come in immediate contact with the realities of their profession in a unique course. They will plan and supervise the actual construction of a modern house. The course will, for the first time, bring to architecture the laboratory method which has proved so successful in science and engineering. It will include the selection and purchase of a suitable lot; making plans and specifications for a moderate size house; selecting a building contractor; and supervision of every step of construction. Upon completion the house will be sold, and the proceeds used to purchase a new location and finance the building of another house for the next year's class.

During the first few weeks of the opening term the class will become familiar with various phases of architectural office practice. It will then make a study of the proposed location, taking into consideration such economic and social factors as transportation, real estate values, taxes, mortgages, deeds, building laws, surveying, and methods of financing.

At the beginning of the second term, the students will prepare preliminary scale sketches for a house to be erected on the chosen lot. This will be developed into a final problem, and the best design chosen as a basis for the house to be built by the class.

From that point on the course will parallel still further the office practice of an architect. Working drawings and specifications will be prepared for the final estimate, bids obtained, and the contract let. The house will be started, and the actual construction followed by the class in every detail. Studies of interior color schemes and landscape treatment of the grounds will complete the project.

The plan is expected to do much to stimulate the beginning student's imagination and interest, and to give him a grasp of the many varied problems of his profession, which usually are encountered only after an architect begins his professional career.

*Course VI*

For the past three years an investigation has been carried on in the Department of Electrical Engineering of the possibility of utilizing vacuum to insulate high-voltage power-generating and converting machinery. This work may ultimately lead to the development of vacuum-insulated electrostatic power machinery for the generation and conversion of direct-current power for transmission systems operating at voltages substantially higher than are now employed. Such systems, it is believed, because of the high-voltage and direct-current character and because of the simplicity and efficiency inherent in electrostatic devices, would remove to a large

extent the present technical and economic limitations to the transmission of large blocks of power over long distances.

The successful development of this new type of power system depends primarily on the adequate realization of the high-voltage insulating properties of vacuum. It would be necessary, for example, to develop vacuum insulation to the point where voltages as high as 500,000 with a gradient of about 2,000,000 volts per centimeter can be safely insulated. With an installation which has recently been completed and especially designed for research on vacuum insulation, direct-current voltages up to 700,000 have been insulated.

The generators and motors of the proposed power system will utilize electrostatic forces developed in high vacuum. The machines are essentially variable condensers with suitable circuit connections and are formed of interleaving metallic discs, the rotors whirling at a high rate of speed, and are inherently capable of developing high voltages directly, operating with an extremely high efficiency, and showing promise of attaining a compactness comparable with present electromagnetic machinery. The first experimental vacuum-electrostatic motor, which was also made to function as a generator, operated on 75 kv. alternating-current with an efficiency of 99 per cent. A direct-current generator designed for 2 kw. of power at 100,000 volts direct current, and physically of the size of a 2 kw. electromagnetic generator, is now awaiting test.

**Michigan State College.**—Professor L. G. Miller, for the past six years Associate Professor of Mechanical Engineering at Michigan State College, has been named Professor and head of the department. Professor Miller takes the place formerly held by Professor H. B. Dirks, now Dean of Engineering.

Mr. Kenneth L. Clark, formerly graduate assistant in Chemical Engineering, has been appointed as an Instructor in this department.

Professor H. S. Reed, head of the Chemical Engineering department, who has been in ill health for the past year is still unable to meet his classes.

The large increase in the number of students in chemical engineering has necessitated an increase in laboratory facilities in this field, and an addition to the industrial chemistry building is contemplated, plans having been completed.

Mr. C. C. Sigerfoos, a graduate of Purdue University, 1930, has been appointed Instructor in Mechanical Engineering in charge of Foundry Practice.

**University of Michigan.**—An outstanding feature of the Summer Session in the College of Engineering was the Engineering Mechanics Graduate School. Through the courtesy and financial assistance of the Chrysler Corporation, it was possible to secure Professor R. V. Southwell of the University of Oxford to assist Professor Timoshenko and other members of the Mechanics Department in conducting a session which offered many unusual courses. Professor Southwell is a Fellow of the Royal Society and a member of the Aeronautical Committee of Great Britain. He is likewise an outstanding authority in the field of Theory of Elasticity and Air-Craft Structures. Professor Timoshenko, who is a regular member of the staff of the University of Michigan is likewise an authority in the field of the Theory of Elasticity, and is responsible for the design of many of the advanced and graduate courses in Mechanics.

Advanced courses were offered during the summer in the Theory of Elasticity, History of Mechanics, Vibration Problems, Fatigue of Metals, Buckling of Thin Plates and Thin Bars, and Photoelasticity. Professors Timoshenko and Southwell conducted a Seminar for graduate students and men from the various industries.

The various courses in Mechanics included likewise a series of special lectures by noted authorities in the field of Theory of Structures. Some of the men who gave these lectures were:

Prof. H. M. Westergaard, University of Ill.
Prof. S. C. Hollister, Cornell University
Prof. Th. von Karman, California Inst. of Technology
Prof. J. P. Den Hartog, Harvard University
Dr. J. N. Goodier, Ontario Research Foundation
Dr. L. H. Donnell, Goodyear-Zeppelin Corporation

The success of these lectures can be gauged by the large attendance of graduate students and engineers from various industries in the State of Michigan. The attendance was approximately one hundred for most of these lectures. Sixty-eight students were enrolled in the regular Summer Session and fifty of these were teachers of Mechanics in other institutions. The Department of Mechanics and the College of Engineering feel that this venture was a notable success.

*Department of Electrical Engineering: Recently Published Reports, Books, Etc.*—"Illumination Distribution from Surface Sources in Rooms," by Professor H. H. Higbie. This was preprinted for the annual meeting of the Illuminating Engineering Society, Cincinnati, September 5, 1935, and will probably be permanently published in the March 1936 Transactions, I. E. S.

Professor M. B. Stout published an article on "Analysis of Rectifier Filter Circuits" in the September, 1935, issue of *Electrical Engineering.*

"Firing Time of an Igniter Type of Tube" by Professor W. G. Dow and Mr. W. H. Powers, formerly a graduate student of this department, appeared in the September issue of *Electrical Engineering.* This paper is to be presented for discussion at the Great Lakes meeting of the A. I. E. E. at Purdue University on October 24–25, 1935.

During the past year and a half Professor W. G. Dow has prepared an 185-page mimeographed text "Electronics and Vacuum Tubes," with accompanying figures for use in course E.E. 12, most of the material therein having been assembled from original sources in technical periodicals, or developed by the author. Additional material is being prepared and it is expected that the entire work will be published in book form some time in the spring of 1936.

Within the past year or so the report to the sponsoring N. E. L. A. Committee on Project 505 of the Department of Engineering Research was put into its final form and submitted to the members of the committee for review. The following are the joint authors of this report:

Professor R. H. Sherlock, Civil Engineering Dept.
Professor M. B. Stout, Electrical Engineering Dept.
Professor W. G. Dow, Electrical Engineering Dept.
Professor J. S. Gault, Electrical Engineering Dept.
Professor R. S. Swinton, Dept. of Engineering Mechanics.

*Unusual Experimental and Research Projects in Progress:* Professor A. D. Moore has continued his work on the development and design of the Hydrocal, which is a new instrument for the solution of heat transfer and temperature rise problems, with the result that the first large-scale unit is now well along in construction.

Under Professor L. N. Holland's direction, research work is being carried on with the Physiology Department. This work consists in the development of high gain amplifiers for the measurement of small action potentials.

*Miscellaneous:* Professor Benj. F. Bailey has been making studies in the theory of sub-synchronous clock motors. It is expected that the results of this investigation will be published in the near future.

Professor A. H. Lovell has worked on the following:

Load curves and operating cost, University of Michigan steam-electric plant.

Investment and operating costs, Wisconsin Diesel-electric plants.

Study of costs for new Federal hydro-electric plants.

Professor S. S. Attwood has continued the development of manuscript material for use in advanced work (E.E. 25, 25a and 27).

**Michigan College of Mining and Technology.**—The college begins its 50th year under a new president, Grover C. Dillman, former state highway commissioner and state welfare director. Mr. Dillman succeeds Dr. W. O. Hotchkiss, who resigned from Michigan Tech in order to assume the presidency of Rensselaer Polytechnic Institute.

Mr. Dillman, who holds a baccalaureate and an honorary degree in civil engineering from Michigan State College, and who is a past president of the Mississippi Valley Association of Highway Departments, took over his duties at Michigan Tech on August 15. He will be formally inducted into office next August, during the combined quinquennial alumni reunion and semi-centennial celebration. Plans are now being laid for this event, and committee chairmen to supervise it will be named by the college board of control within a month.

Governmental and educational leaders not only from Michigan but from many other parts of the United States are expected to attend, including delegates from the seven organizations represented in the Engineers' Council for Professional Development.

A 16 per cent increase in the freshman enrollment, the offering (by arrangement with the University of Michigan forestry school) of a first-year curriculum in forest production and wood utilization, and the financing of five building and landscaping projects by means of a grant of $109,000 from the WPA, have been among the leading events of the autumn term. In extra-curricular activities the outstanding matters have been the formation of Pi Lambda Kappa, honorary electrical engineering fraternity, and the scheduling of home-and-home intersectional football games with the Montana School of Mines.

Promotions announced during the summer by the board of control are: J. M. Harrington and Fay Partlo of the Mathematics and Physics Department from Assistant to Associate Professors; Drs. L. A. Rose of the English staff and E. W. Schilling of the Electrical Engineering staff from Assistant to Associate Professors; J. L. Byers (Metallurgy), Russell Johnson (Mechanical Engineering), H. E. Krumlauf (Mining Engineering), D. P. Sherman (Economics), and Frank Tolonen (Metallurgy) from Instructors to Assistant Professors; Walter Keck from Research Assistant to Research Engineer in Metallurgy; and Kiril Spiroff from Laboratory Assistant to Instructor in geology. Mr. Spiroff was also appointed Assistant Curator of the Mineralogical Museum.

New appointments include that of Richard J. W. Koopman, who

holds an M.S. degree from Yale and has completed most of his work for the Ph.D. degree at the University of Missouri, as Instructor in Electrical Engineering; and of Frank Fisher as laboratory assistant in Roentgenology. Charles Rohrman was given a temporary appointment in the Department of Chemistry during the absence on leave of Dr. F. A. Rohrman, now at the Fort Sill (Okla.) training school as captain in the U. S. Field Artillery. Dr. Irwin Roman of the Mathematics and Physics Department is also on leave, being engaged in geophysical work outside the college.

**University of Nebraska.**—There are two new appointees in the faculty of the College of Engineering this fall. Mr. Niles H. Barnard is a new instructor in Mechanical Engineering, taking the place of Professor Clarence A. Sjogren, resigned. Mr. Barnard is a graduate of the University of Illinois, from which school he has three engineering degrees. His industrial experience has been with the Illinois Structural Steel Company and the Illinois Central Railroad. Previous to coming to Nebraska, Mr. Barnard was Associate Professor of Mechanical Engineering at the Tennessee Polytechnic Institute. He is a member of A. S. M. E., S. P. E. E., Tau Beta Pi, Sigma Xi.

Mr. Albert LeRoy Pugsley has been appointed Instructor in Architectural Design. Mr. Pugsley is a graduate of South Dakota State College, with graduate degree from Harvard University. He has just returned from abroad where he spent a year with a travelling fellowship awarded by Harvard University.

A series of meetings of our Course of Study Committee ran through all of the last school year, for the purpose of presenting in detail and discussing all college courses common to two or more groups of study. Syllabi were presented by the departments concerned, methods of instruction were described, as were also correlations with other courses. A free discussion by all faculty members ensued after each presentation, and new possibilities of interdepartmental contacts and coöperation were developed.

It is planned to study in great detail this year, curriculum revisions suggested by the earlier survey.

The Kansas–Nebraska Section of S. P. E. E. met at Lincoln on November 1 and 2.

**University of North Dakota.**—The general enrollment and that in engineering shows a slight increase over that of 1934–35.

Alfred G. Boyd, Professor of Civil Engineering, has taken a leave of absence to work as engineer examiner for the North Dakota P.W.A. administration at Bismarck. His courses are being handled

by Elder Lium, 1921, City Engineer of Grand Forks, who taught half-time last year in that division.

Alexis J. Diakoff, Professor of Mechanical Engineering, has taken a leave of absence for the year to teach in the Hemphill Diesel Engineering School in Los Angeles and to study at the California Institute of Technology.

O. T. Zimmerman, Ph.D. in Chemical Engineering at University of Michigan, 1934, is instructor in Chemical Engineering for 1935–36. He has had several years experience in chemical industries.

Albert M. Cooley, M.S. in Chemical Engineering, 1931, who has had several years experience in chemical industries is teaching in Chemical Engineering.

Arthur Koth, M.S. in Chemical Engineering, 1931, who has specialized in fuels is also teaching in Chemical Engineering.

W. E. Budge, E.M. 1911, Professor of Ceramic Engineering, has returned after a year's leave of absence spent on special engineering work with the North Dakota Administration of F. E. R. A.

Dr. Irvin Lavine, Professor of Chemical Engineering, is continuing his work as Technical Consultant to the State Planning Board as well as Coordinator of Research Projects for the W.P.A. and has had his leave extended for another semester. His office is located on this campus.

The College of Engineering is now represented at Oxford by two of its graduates: Robert Moore, B.S. in E.E.; William Franta, M.S. in Chem. Eng. These two men are the first North Dakotans to win Rhodes Scholarships since the appointments have been made from groups of states.

The College of Engineering at the **University of Missouri** is fortunate in sharing generously in the building program on the campus this year, which in total amounts to over $1,400,000.

The old wooden and brick Engineering Annex Building which housed electrical and mechanical engineering laboratories, is to be replaced by a much larger fireproof structure. The main portion of the new Engineering Laboratories Building will be three stories and provide minor laboratory space, offices, classrooms and enlarged library facilities. The attached portion, containing the principal laboratories for electrical, mechanical and chemical engineering, will have a mezzanine floor in each laboratory offering a series of small laboratories particularly designed for research and special problem work. The entire building of seventy rooms, including the three story structure, is designed on a unit system so that partition walls may be readily moved and each unit including all rooms initially designated as offices or classrooms, may on short

notice be transformed into laboratories with piping and connections ready for supplies of water, gas, compressed air and electricity.

In addition to this entirely new building, the Mechanic Arts Building is now being rebuilt and refinished while the main Engineering Building is to be entirely renovated and relighted.

Changes in staff are as follows:

F. Ellis Johnson, formerly Head of the Department of Electrical Engineering at Iowa State College, at Ames, succeeds Dean E. J. McCaustland, retired, as Dean of the College.

R. B. B. Moorman, of the faculty at the University of Mississippi, comes as Assistant Professor of Civil Engineering to fill the position made vacant by the retirement of Professor A. Lincoln Hyde.

R. L. Scorah, formerly on the staff at Leland Stanford, takes the place of Professor G. D. Newton, retired, with rank as Assistant Professor of Mechanical Engineering.

Note should also be made of the retirement of Professor W. S. Williams, Professor of Civil Engineering.

**Newark College of Engineering.**—The Chemical Engineering Laboratory has been enlarged by the addition of a nineteen plate rectifying column arranged so that the bubble cap action can be observed through pyrex walls. A fifty gallon kettle, four 22 gallon receivers and all necessary equipment such as heat interchangers, meters and gauges are used in conjunction with the still.

Other pieces of equipment added have been a small steam heated cabinet drier with forced circulation as well as a Vulcan all-copper, single effect evaporator for the study of rate of evaporation; rate of heat transfer and evaporation principles in general.

Both the Electrical Engineering Laboratory and the Metallography and Heat Treatment Laboratory have been enlarged. The Metallography and Heat Treatment Laboratory has been moved to a new location and a rapid expansion is anticipated.

The faculty of the college has been enlarged by the acquisition of four members, two of whom have returned after a year's industrial experience. Mr. Wilkinson returned to the Department of Industrial Engineering after having been connected with the United Parcel Service, doing time study work. Mr. Mainardi has returned to the Department of Mathematics after having been assistant manager for a rayon manufacturer.

Two new additions to the faculty have been made in the appointment of Mr. Calendar, who was previously connected with the Passaic Vocational High School. Mr. Calendar divides his time between the Department of Mathematics and the Department of Mechanical Engineering.

Mr. Scheller, another new comer to Newark, was connected with the Wright Aeronautical Corporation and is now connected with the Department of Mechanical Engineering devoting his time to the Mechanical Engineering Laboratories.

The Newark College of Engineering Branch of the S. P. E. E. is looking forward to an active year. It is expected that reports of several educational studies will be heard during the coming year.

**Ohio State University.**—Mr. Hurlbut S. Jacoby has assumed his duties as Director of Industrial Research of the Engineering Experiment Station. He comes to the University from Cleveland, after wide experience in industry. He is a son of Emeritus Professor Henry S. Jacoby of Cornell University.

The enrollment for the College of Engineering for the Autumn Quarter, 1935, is (including 149 in Applied Optics) 1,605, an increase of nearly 10 per cent over 1934. This includes 473 freshmen and 106 students who transferred from other universities as upper classmen. The total new admissions to the Ohio State University, as of September 27 (opening date of Freshman Week) were 4,375, an increase of 18 per cent over 1934 and 46 per cent over 1933. Of these, 3,314 were Freshmen, an increase of 18 per cent over 1934 and 58 per cent over 1933. This is the largest Freshman Class in the history of the University. It is likely that the total registration will exceed 11,300.

Mr. Lawrence L. Quill is the new Assistant Professor of Chemistry. He was previously at the University of Nevada and the University of Illinois, and takes the place of Professor Jesse E. Day, who died suddenly last May. Other new instructors in the Department of Chemistry are: Arnold A. Alberts from the University of South Dakota and University of Oklahoma; Alfred B. Garrett from Muskingum College; and J. L. Hoard from University of Washington and California Institute of Technology.

Associate Professor Ralph W. Powell of the Department of Mechanics has returned after a year's leave of absence, during which he acted as a consultant on the hydraulic problems of the Muskingum Conservancy District at the New Philadelphia, Ohio, office. This project, for which the Federal Government is furnishing $22,090,000 affects nearly one-fifth the area of the State of Ohio. Assistant Professor LeRoy Tucker, who filled this vacancy last year, remained on account of the increased enrollment occurring during the past two years in the College of Engineering.

The Civil Engineering Department reports all available graduates are employed, with about 50 calls for men still unfilled. Of these about 40 are for men with experience.

Dr. James R. Withrow, Chairman of the Department of Chem-

ical Engineering, Ohio State University, delivered the commencement address at Geneva College, Beaver Falls, Pa., in June. Dr. Withrow talked on "Engineering Methods and Man's Ultimate Problem, Himself." The College conferred upon Dr. Withrow the honorary degree of Doctor of Science for outstanding work as a teacher and engineer. During the previous year Dr. Withrow gave one of the four Commencement Addresses at the Ohio State University on a related subject.

Assistant Professor Harold L. Hazen has returned to Massachusetts Institute of Technology after a year with the Department of Electrical Engineering here. Assistant Professor John F. Byrne of Ohio State University was exchange professor for him at Boston.

Professor John Younger, Chairman of the Department of Industrial Engineering, spent three months during the past summer at Akron making a survey of the efficiency, personnel, and administrative details of the Summit County offices for the County Commissioners. He made an extensive report, recommending changes and rearrangements in offices, records and administrative details, and stabilization of salaries, looking to less red tape and more efficient management of the County's business offices.

**Purdue University.**—*New Staff Members.*

*Chemical Engineering:* Edward C. Miller, Instructor, B.S. Missouri School of Mines; M.S. University of Idaho. Experience: Development engineer, St. Joseph Lead Company; Research Fellow, Bureau of Mines. David J. Mack, Assistant, B.S. and M.S. University of Wisconsin. Experience: Junior Engineer, C. F. Burgess Laboratory; Globe Union Manufacturing Company.

*Civil Engineering:* L. H. Kemmer, Jr., Assistant, B.S. Purdue University. J. D. Richetta, B.S. Purdue University.

*Electrical Engineering:* C. B. Aiken, Associate Professor, B.S. Tulane University; M.S. Columbia; M.A. and Ph.D. Harvard University. Experience: Bell Laboratories, Columbia University. R. B. Marshall, Assistant, B.S. Purdue University. Experience: Assistant to Dean, Columbus, Ohio, Y. M. C. A.

*Mechanical Engineering:* Lillian M. Gilbreth, Professor of Management, B.Litt. and M.Litt. University of California; Ph.D. and Sc.D. Brown; M.Eng. Michigan; Dr.Eng. Rutgers; Sc.D. Russell Sage; LL.D. California. K. C. Ripley, Instructor, B.S. University of Arkansas; M.S. University of Pittsburgh. Experience: Westinghouse Electric Company. H. N. Harmon, Assistant, B.S. University of Minnesota.

*Practical Mechanics:* G. O. Ashman, Instructor, B.S. Purdue University. M. R. Graney, Instructor, B.S. Purdue University. H. C. Thompson, Jr., Instructor, B.S. University of Kentucky.

Experience: University of Colorado, University of Iowa, National Board for Aeronautics, Indian Refining Company. F. W. Duff, Assistant, B.S. Purdue University.

*Engineering Experiment Station:* J. G. Miller, Assistant, B.S. Purdue University.

*Engineering Extension:* Franklin M. Kreml, Specialist in Public Safety, University of Wisconsin; Northwestern University; LL.B. John Marshall Law School. Experience: Cook County Highway Department; U. S. Bureau of Public Roads; Director, Bureau of Accident Prevention, Evanston, Illinois. A. R. Simpson, Assistant, B.S. Purdue University.

*Personnel:* L. C. Hull, Assistant, B.S. Iowa State College. Experience: Iowa Engineering Experiment Station. J. H. Calvert, Assistant, B.S. Purdue University. Experience: Emerson Electric Manufacturing Company.

### *Staff Promotions and Changes*

*Promotions: Applied Mechanics:* H. F. Girvin from Assistant Professor to Associate Professor.

*Chemical Engineering:* J. L. Bray from Professor of Metallurgy to Head of the School of Chemical Engineering and Professor of Metallurgy. F. L. Serviss from Associate Professor to Professor of Engineering Geology.

*Civil Engineering:* R. B. Crepps from Assistant Professor to Associate Professor. W. J. Henderson from Assistant Professor to Associate Professor. M. W. Todd from Assistant Professor to Associate Professor.

*Electrical Engineering:* E. M. Sabbagh from Instructor to Assistant Professor. J. H. Karr from Assistant to Instructor. B. H. Short from Assistant to Instructor.

*Administration:* W. A. Knapp to Assistant Dean of Engineering with the rank of Professor.

*Personnel:* J. E. Walters from Director of Personnel to Professor of Personnel Administration.

*Resignations: Chemical Engineering:* C. R. Lillie, Assistant, resigned to enter industry.

*Electrical Engineering:* Alfred Still, Professor, retired. G. E. West, Assistant Professor, resigned to take charge of Police Radio, State of Illinois. J. W. Stafford, Instructor, resigned to enter industry.

*Mechanical Engineering:* C. L. H. Wagner, Instructor, resigned to enter industry. J. A. Bolt, Assistant, resigned to enter industry.

*Enrollment:* The undergraduate enrollment on October 1, 1935 was 2,547 or about 350 more than a year ago. The freshman class

has 990 as compared with 739 a year ago; the sophomore class, 660 as compared with 541 a year ago; the junior class, 499 as compared with 471 a year ago. The senior class, however, is 400 as compared with 458. No data are available up to date on the enrollment of graduate students as the schedules of these have not been completed. Apparently there will be about 100 graduate students in engineering and possibly six or seven specials making a total of between 2,650 and 2,700.

*New Curricula:* During the past year Purdue University has developed a curriculum in Public Service Engineering which has as its objective the preparation of a selected group of people for government service. This program of study includes basic instruction in elements of civil, electrical and mechanical engineering, and has the same science and mathematical requirements as the standard professional curricula. The student, however, devotes about 20 per cent of his time to special courses in government, politics and social sciences.

Purdue University is also coöperating with Indiana University in offering a curriculum in engineering law. The student devotes the first three years at the Law School of Indiana University. He receives the degree of B.S. from Purdue University and LL.B. from Indiana University.

**Rhode Island State College.**—We are in the midst of a P.W.A. building program totaling about one and a quarter millions of dollars. Included in this program are: An enlarged water supply; a new Home Economics Building; a new Administration and Library Building; Womens Dormitory; Dairy Barn; Cafeteria; remodelled and enlarged Power Plant, oil fired; new quarters for the Department of Physics; providing major buildings with sprinkler systems.

Present enrollment, 1,106—an increase of about 6 per cent over any previous year.

This year's graduating class, to qualify for a degree, must meet the requirement, not only of passing all courses, but of making an *average* standing of "C" for their entire course.

Mr. Igor Sikorsky will have charge of the option in Aeronautics and will come to the College for frequent lectures and consultations.

The position of Instructor in Shop Work, left vacant last spring by the death of Mr. F. F. Archibald, has been filled by the appointment of the latter's son, W. D. Archibald, formerly assistant. Mr. Robert Gough, for many years in charge of forging has been appointed as assistant in Shop Work.

**Rose Polytechnic Institute.**—Mr. Herman Moench, of the Department of Electrical Engineering, has been granted leave of absence for the year to complete his work for the doctor's degree at the University of Michigan. His position has been filled by the appointment of Mr. Karl Spangenberg, a graduate of Case.

Mr. Harve N. Chinn has been promoted to an assistant professorship of Civil Engineering, and Dr. Paul Hoel to an assistant professorship of Mathematics.

**South Dakota State School of Mines.**—South Dakota Regents of Education elected Dr. Joseph P. Connolly to assume the presidency of the State School of Mines, left vacant by the recent death of C. C. O'Hara, former president.

Other changes in personnel this year include Warren Wilson, from California Tech, in the Civil Engineering Department, and Dr. Tullis of the University of Chicago as Assistant Professor of Geology.

L. R. Palmerton, University of Minnesota, was added to the faculty as Instructor in English and Social Sciences. A new course in Industrial Psychology is a recent addition to the School of Mines curriculum.

C. M. Rowe, Head of the English Department, has now an associate professorship in English and Social Science. Mr. Rowe is also in charge of the broadcasting station WCAT, located on the campus.

**Stevens Institute of Technology.**—The fifth annual Economic Conference for Engineers was held at the Stevens Engineering Camp, Johnsonburg, N. J., August 10–18, 1935. There were 92 enrollments for the conference, 46 representing 25 colleges, 46 colleges unknown.

W. D. Ennis, Professor of economics of engineering was Director of the conference. The subject discussed was "Taxation and the Cost of Government." Some of the speakers were Harold G. Hoffman, Governor of New Jersey; Col. H. Norman Schwarzkopf, Supt. of N. J. State Police; C. P. Messick, Chief Executive, N. J. Civil Service Commission; Jos. D. M. Goldrick, formerly Comptroller, City of New York; Louis M. Faulkner, Deputy Chamberlain, New York City; Thos. H. Reed, Director, Municipal Consultant Service; C. E. Righter, Municipal Credit Dept. of Dun and Bradstreet; Professors John F. Sly, Carl Shoup, Paul Studenshi, and John E. Bebout.

William S. Barstow, Trustee and Vice-Chairman of the Board has proffered a gift to the college of $150,000. This gift is for the erection of a college building in accordance with preliminary studies made at Mr. Barstow's request.

Dr. William E. Geyer, Professor Emeritus of Physics at Stevens, last surviving member of the original faculty of 1870, died October 8, 1935, at his home in Boonton, N. J., at the age of 87.

**Swarthmore College.**—New appointments: George B. Thom, Assistant Professor of Mechanical Engineering, formerly an Instructor at Lehigh University. Samuel T. Carpenter, Instructor in Civil Engineering, formerly Instructor and Research Engineer at Ohio State University. John D. McCrumm, Instructor in Electrical Engineering, formerly with the General Electric Company, Schenectady, N. Y.

**Texas Technological College.**—In our Department of Architecture and Allied Arts Mr. Robert I. Lockard has accepted the position of Assistant Professor of Architecture. Mr. Lockard holds the degrees of B.S. and M.S. in Architecture, Kansas State College of Agriculture and Applied Science. Until recently Mr. Lockard was connected with the William Rockhill Nelson Gallery of Art, Kansas City, Missouri.

Mrs. Floy F. Hooper has been employed as a part-time instructor in this Department. She received her B.A. degree from Chicago Art Institute, and has had a number of years experience as supervisor of art in public schools.

In the Department of Industrial Engineering, Engineering Drawing, and Industrial Education Mrs. Margaret Brashears Atkinson has been employed as Instructor in Engineering Drawing.

Department of Mechanical Engineering: Mr. Ralph E. Lewis resigned in the spring of 1935. His place has been taken by Mr. Roger Clapp, B.S. in Mechanical Engineering, Texas Technological College. Mr. Clapp was employed by the W. F. Curlee Manufacturing Company, Houston, Texas.

Department of Textile Engineering: Professor Carl Brandt resigned to accept a position with the Whitin Machine Works, Whitinsville, Massachusetts. Associate Professor M. E. Heard who has taught in this Department for several years has been made Acting Head of the Department.

Mr. R. F. Redding, B.S. in T.E., 1932, Georgia School of Technology, has been appointed as Assistant Professor of Textile Engineering. Mr. Redding was designer for the Aiken Mills, Langley, South Carolina, before accepting the position here.

This year our Department of Civil Engineering has added a new curriculum leading to the degree Bachelor of Science in Civil Engineering, Municipal Engineering Option. This option will provide a thorough training in the basic engineering subjects.

Some of the more specialized engineering courses have been displaced by courses in Economics, Business Administration, and Government.

**Tulane University.**—Dean Douglas S. Anderson has been elected Acting President of Tulane University for 1935–1936. This office was left vacant by the recent death of President Dinwiddie. Dean Anderson is President of the S. P. E. E. for 1935–1936 also. Professor James M. Robert has been elected Acting Dean of the College of Engineering for the same period.

**Virginia Polytechnic Institute.**—Dr. Samuel Reynolds Pritchard, for forty-two years head of the Electrical Engineering Department, died suddenly on September 30 while on his way to meet his classes.

Francis J. Sette, Associate Professor of Sanitary Engineering, is on leave of absence for the session 1935–1936. Professor Sette is acting as Director of the Works Progress Division, Resettlement Administration in Washington, D. C. His place is being taken by Eugene C. Meredith, of the engineering staff of the Virginia State Board of Health.

Dr. Frank C. Vilbrandt, formerly at the Iowa State College, has assumed his duties as Professor of Chemical Engineering.

Mr. Paul P. Stewart, Instructor in Architectural Engineering, is on leave of absence in the Architectural Division of the Resettlement Administration. His place is being filled by Mr. Pasqual Torracca, University of Pennsylvania, 1920.

Among the new buildings opened for use this fall is a faculty apartment house and social center which has been erected with P. W. A. funds. The building is unique in its purpose and fills a long-felt want. Besides a number of apartments ranging from one to five rooms for faculty members and their families, it contains dining facilities, lounges, library, small auditorium and other social facilities for the use of the general faculty. This building, with the nearby University Club building, which houses the bachelor instructors, forms a rather complete social group for the faculty.

**Washington University.**—At a meeting of the faculty of the School of Engineering held last spring there was adopted a new four-year curriculum leading to the degree of Bachelor of Science in Engineering Administration. This curriculum was duly approved by the Corporation and went into effect with the beginning of the present college year with an encouraging initial registration.

This year's registration in Engineering represents an increase over last year of nearly 9 per cent.

**University of Washington.**—Additions have been made to the Engineering staff this year as follows:

John R. Woodyard, B.S. in E.E., University of Washington, 1933 Instructor in Electrical Engineering.

Paul L. Morton, B.S. in E.E., University of Washington, 1931 Instructor in General Engineering.

Edgar Allen Loew, Dean, College of Engineering.

The following will be of interest since it is a new departure with us. Members of the Engineering Faculty this year are giving a series of twenty talks of fifteen minutes each which will be broadcast over the radio. The subject matter of these talks will be engineering applications of interest in the several fields of engineering.

**Worcester Polytechnic Institute.**—Many additions and improvements have been made in laboratories and equipment during the past year. A specially designed, new Electronics Laboratory, with modern equipment is nearing completion in the Electrical Engineering Building. The Chemistry Laboratories have been greatly improved and brought up to date. The Power Plant and Mechanical Engineering Laboratories recently installed a new, 4-drum water-tubular boiler, with instrument board, diesel engine equipment, and centrifugal and turbine machinery.

Our entire curriculum is receiving constant study and is now being broadened and various technical courses modernized. In our requirements for the B.S. degree, 2½ more semester hours are now devoted to the subjects of English, History, Languages, Government, Economics, Business Law, Political Science, and Elements of Business for the Engineer.

A thorough study has been made of the Descriptive Geometry and Drawing Courses during the past year resulting in the adoption of new methods of teaching which makes these courses more interesting and instructive.

Dr. Richard A. Beth of the Physics Department has returned to the Institute after a year spent at Princeton University as Research Associate. Robert T. Young, Jr., has joined the Physics Department staff. He is a graduate of the University of Montana and has taken graduate work at the University of Illinois and Harvard. During the summer he was associated with Dr. Arthur H. Compton in studies of cosmic rays.

**University of Wyoming.**—Dean R. D. Goodrich, Dean of Engineering and Professor of Civil Engineering, has been named Consulting Engineer for the United States Engineer's Office at Portland, Oregon. He will direct and supervise Flood Frequency Studies of the Willamette River in Oregon. This work will necessitate a trip to Oregon about once a month during the winter.

Mr. A. J. McGaw, who received his B.S. degree from the University of Wyoming in 1933, has been added to the staff as Instructor in Civil Engineering. Prior to coming to the University of Wyoming, Professor McGaw was associated with the Bridge Department of the Wyoming Highway Commission and the United States Bureau of Reclamation. Mr. McGaw has also spent two years in South America as an engineer for the Standard Oil Company of New Jersey.

The enrollment in the University of Wyoming Engineering College during the present term has exceeded that of the fall term of 1934 by 35 per cent. This has necessitated additional drafting room space and equipment.

**Yale University.**—Barnett F. Dodge, who has been Acting Chairman of the Department of Chemical Engineering, has been made Chairman of that Department. He succeeds Dr. Harry A. Curtis, who is now Chief Chemical Engineer for the Tennessee Valley Authority. Professor Dodge was born in 1895 at Akron, Ohio. He graduated from the Massachusetts Institute of Technology, and has since been both a graduate student and a lecturer at Harvard. He also lectured at Worcester Polytechnic Institute before coming to Yale in 1925 as Assistant Professor of Chemical Engineering. He was promoted to an Associate Professorship in 1930 and to a professorship last July. In addition to his educational work, Professor Dodge has had a number of years of industrial experience with E. I. du Pont de Nemours and Company, with the Lewis Recovery Corporation, and with the Fixed Nitrogen Laboratory of the U. S. Department of Agriculture. In coöperation with the Mellon Institute of Industrial Research he investigated the high pressure synthesis of methanol. He has been consultant to the Oxygen Process Corporation of New England, and is consultant to the Connecticut State Water Commission, in which connection he has done extensive and valuable work in developing processes for the treatment of pickling wastes.

Mr. R. H. Newton, for several years Instructor in Chemical Engineering, has left Yale to take a position with the Tennessee Valley Authority. Mr. Frederick Bellinger, a graduate of the Georgia School of Technology and of Emory University, and formerly connected with the Roessler and Hasslacher Chemical Com-

pany and with the Chemical Warfare Service at Edgewood Arsenal, has joined the Department as an Instructor. Mr. Roy S. Arrandale, a graduate of the University of Illinois and of the Carnegie Institute of Technology, and formerly with the Thatcher Manufacturing Company, has also been made an Instructor in the Department.

Mr. Ralph E. Pumphrey has been made an Instructor in the Electrical Engineering Department. Mr. Pumphrey is a graduate of Miami University and of Yale, from which he took his doctor's degree in 1934.

Mr. T. H. Evans, formerly Instructor in Engineering Mechanics, resigned that position last June and is now Assistant Professor of Civil Engineering at the University of Virginia.

## NEW MEMBERS

ADAIR, FRANK H., Instructor in Machine Design, Kansas State College of Agriculture and Applied Science, Manhattan, Kansas. C. H. Scholer, C. E. Pearce.

BAXTER, CHARLES H., Professor of Civil and Mining Engineering, Michigan College of Mining and Technology, Houghton, Michigan. G. W. Swenson, E. W. Schilling.

BEST, HERBERT W., Assistant Professor of Mechanical Engineering, Yale University, New Haven, Conn. L. C. Lichty, C. T. Bishop.

BIRD, JOHN M., Instructor in Civil Engineering, Southern Methodist Universvrsity, Dallas, Texas. E. H. Flath, Ralph E. Lewis.

BLACK, RALPH P., Associate Professor of Civil Engineering, Georgia School of Technology, Atlanta, Ga. R. S. King, F. A. Snow.

BOHLIN, HOWARD G., Assistant Curator; Assistant Professor of Drafting, The City College of the City of New York, New York City. Harry Baum, G. C. Autenrieth.

BRAMER, CHARLES R., Assistant Professor of Civil Engineering, North Carolina State College, Raleigh, N. C. R. P. Kolb, H. B. Shaw.

BROWN, RICHARD E., Associate Professor of Electrical Engineering, New York University, N. Y. S. K. Barrett, A. C. Coonradt.

BRUBAKER, JASPER L., Instructor in Machine Design, Kansas State College, Manhattan, Kans. G. F. Branigan, C. E. Pearce.

CALENDAR, H. LANE, Instructor in Mechanical Engineering, Newark College of Engineering, Newark, N. J. F. D. Carvin, S. Fishman.

CHASE, CHARLES H., Professor of Steam Engineering, Tufts College, Tufts College, Mass. G. P. Bacon, R. W. Lefavour.

CHASE, HUGH D., Assistant Professor of Civil Engineering, University of Maine, Orono, Me. E. J. Felker, E. H. Sprague.

CLAPP, M. ROGER, Instructor in Mechanical Engineering, Texas Technical College, Lubbock, Texas. V. L. Doughtie, H. F. Godeke.

COBB, ARNOLD C., Instructor in Mechanical Engineering, University of Minnesota, Minneapolis, Minn. C. F. Shoop, J. R. Du Priest.

DESCHNER, WALTER W., Instructor of Industrial Chemical Engineering, Pratt Institute, Brooklyn, N. Y. F. L. Schwartz, S. S. Edmands.

DOHRENWEND, CLAYTON O., Instructor in Civil Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. E. R. Cary, H. P. Compton.

FAWCETT, CHARLES DEVAN, Professor of Electrical Engineering, Moore School, University of Pennsylvania, Philadelphia, Pa. G. E. Crofoot, R. H. Fernald.

FRANK, HARRY C., Assistant Professor of Physics, Stevens Institute of Technology, Hoboken, N. J. H. N. Davis, F. D. Furman.

GAGER, FRANK M., Professor of Physics, Boston College, Boston, Mass. Carlton E. Tucker, Clifford E. Lansil.

GIANNINI, MARIO C., Faculty Lecturer Heat and Ventilation, New York University, New York. S. K. Barrett, C. E. Gus.

HAAS, MATTHIAS E., Professor of Chemical Engineering, University of Dayton, Dayton, O. B. T. Schad, M. B. Grandy.

HAWKINS, JOHN E., Associate Professor of Chemical Engineering, University of Florida, Gainesville, Fla. B. R. VanLeer, N. C. Ebaugh.

HAYES, ST. CLAIR J., Lecturer in Engineering, Memorial University College, St. John's, Newfoundland. Geo. Alan Frecker, F. L. Bishop.

HAZELL, WILLIAM, JR., Instructor in Physics, Newark College of Engineering, Newark, N. J. S. Fishman, F. N. Entwisle.

HEARD, M. E., Acting Head, Textile Engineering, Texas Technological College, Lubbock, Tex. O. V. Adams, J. H. Murdough.

HILLBERRY, NORMAN, Assistant Professor of Physics, New York University, New York City. S. K. Barrett, C. E. Gus.

HINTON, WILLIAM A., Instructor in Mechanical Engineering, Georgia School of Technology, Atlanta, Ga. W. V. Dunkin, R. S. Sweigert.

HUGHES, FORREST R., Assistant Professor of Engineering Drawing, Yale University, New Haven, Conn. C. T. Bishop, J. N. Eckel.

HUMPHREY, HOMER, Instructor in Civil Engineering, Michigan College of Mining and Technology, Houghton, Mich. G. W. Swenson, E. W. Schilling.

JOHNSON, RUSSELL H., Assistant Professor of Mechanical Engineering, Michigan College of Mining and Technology, Houghton, Mich. G. W. Swenson, E. W. Schilling.

KAYAN, CARL R., Instructor in Mechanical Engineering, Columbia University, New York City. F. W. Hehre, Walter A. Curry.

KOZLOWSKI, EDWARD, Instructor in Civil Engineering, Lewis Institute, Chicago, Ill. J. G. Bennett, R. B. Parks.

KUHZEN, FREDERICK, Assistant Professor of Mechanical Engineering, The College of the City of New York, New York City. A. Bruckner, George Autenrieth.

LANGE, PAULUS, Associate Professor of English, Iowa State College, Ames, Iowa. Re-instatement.

LANSFORD, WALLACE, Associate in Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill. M. L. Enger, Jasper O. Draffin.

LYNCH, WILLIAM, Associate Professor of Physics, New York University, New York City. S. K. Barrett, C. E. Gus.

LYON, ALPHEUS C., Associate Professor of Civil Engineering, University of Maine, Orono, Me. W. S. Evans, Paul Cloke.

MAILHIOT, ADHEMAR, Dean of Engineering, Ecole Polytechnique, Montreal, Canada. A. Frigon, A. Circe.

MAINARDI, POMPEY, Assistant Instructor in Mathematics, Newark College of Engineering, Newark, N. J. S. Fishman, J. H. Fithian.

MASSON, HENRY J., Professor of Chemical Engineering, New York University, New York City. S. K. Barrett, D. B. Porter.

MCCUEN, THERON L., Teacher, Kern County Junior College, Bakersfield, Calif. K. W. Rich, T. S. Taber.

MCNAIR, ARTHUR J., Instructor in Civil Engineering, University of Colorado, Boulder, Colo. H. S. Evans, C. L. Eckel.

MOREHOUSE, J. STANLEY, Professor of Mechanical Engineering, Villanova College, Villanova, Pa. C. G. Thatcher, H. L. Bueche.

PARRE, EDWIN M., Instructor in Mechanical Engineering, Lewis Institute, Chicago, Ill. J. G. Bennett, R. B. Parks.

PEARL, WILLIAM A., Associate Professor of Mechanical Engineering, Armour Institute of Technology, Chicago, Ill. J. B. Finnegan, H. T. Heald.

PHILLIPS, ERNEST C., Professor of Shop Production, University of Missouri, Columbia, Mo. E. S. Gray, R. W. Selvidge.

PHILLIPS, HENRY B., Professor of Mathematics, Massachusetts Institute of Technology, Cambridge, Mass. C. E. Tucker, C. E. Lansil.

POTTER, JAMES G., Instructor in Mathematics, Armour Institute of Technology, Chicago, Ill. J. B. Finnegan, E. H. Freeman.

PRATT, GROVER M., Assistant Professor of Architectural Engineering, Iowa State College, Ames, Ia. F. C. Miller, O. A. Olson, H. J. Gilkey.

REED, HENRY R., Associate Professor of Electrical Engineering, Michigan College of Mining and Technology, Houghton, Mich. G. W. Swenson, E. W. Schilling.

RISTEEN, HORACE W., Assistant Professor of Mechanical Engineering, Michigan College of Mining and Technology, Houghton, Mich. E. R. Wilcox, F. M. Warner.

ROWLANDS, THOMAS M., Assistant Professor of General Engineering, University of Washington, Seattle, Wash. E. R. Wilcox, F. M. Warner.

SEELEY, LAUREN E., Assistant Professor of Mechanical Engineering, Yale University, New Haven, Conn. L. C. Lichty, C. T. Bishop.

SHEDD, PAUL C., Assistant Professor of Electrical Engineering, Newark College of Engineering, Newark, N. J. S. Fishman, J. C. Peet.

SMITH, EASTMAN, Associate Professor of Physics, Newark College of Engineering, Newark, N. J. S. Fishman, J. A. Weishampel.

SMITH, EDWARD F., Assistant Professor of Electrical Engineering, University of Florida, Gainesville, Fla. B. R. Van Leer, Jos. Weil.

SPARROW, THEORN A., Instructor in Mechanical Engineering, University of Maine, Orono, Me. H. D. Watson, I. H. Prageman. (Re-instatement.)

STEPHANS, CLARENCE H., Instructor in Electrical Engineering, Newark College of Engineering, Newark, N. J. S. Fishman, A. S. Kohler.

STURMER, ANNA M., Associate Professor of English, Kansas State College, Manhattan, Kansas. R. A. Seaton, L. E. Conrad.

TEA, PETER L., Instructor in Drafting, College of the City of New York, New York City. E. Neus, Fred. Skene.

VAN BUREN, MILES H., Instructor in Civil Engineering, Cooper Union, New York City. F. E. Foss, Lawrence Perez.

VAN WINKLE, EDWARD H., Professor of Business Administration, Rensselaer Polytechnic Institute, Troy, N. Y. E. R. Cary, J. B. Fairfield.

VENNARD, JOHN K., Instructor in Civil Engineering, New York University, New York City. S. K. Barrett, Thorndike Saville.

WIDENER, BURTON M., Assistant Professor of Electrical Engineering, Virginia Polytechnic Institute, Blacksburg, Va. D. H. Pletta, P. T. Norton, Jr.

WILLIAMSON, H. DUFF, Instructor in Civil Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. E. R. Cary, H. B. Compton.

WILSON, JOHN W., Instructor in Electrical Engineering, University of Florida, Gainesville, Fla. Jos. Weil, B. R. Van Leer.

WILTSE, STANLEY B., Associate Professor of Electrical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. E. R. Cary, H. B. Compton.

WING, ALEXANDER H., JR., Instructor in Electrical Engineering, College of the City of New York, New York City. H. Baum, G. C. Autenreith.

WOOD, ELLA L., Professor of Geography and Languages, Michigan College of Mining and Technology, Houghton, Mich. G. W. Swenson, E. W. Schiller.

YASINES, STAN F., Instructor in Civil Engineering, New York University, New York City. D. S. Trowbridge, C. T. Schwartz.

YOUNG, ALMON P., Assistant Professor of Mechanical Engineering, Michigan College of Mining and Technology, Houghton, Mich. G. W. Swenson, E. W. Schilling.

ZELIFF, DAVID E., Instructor in Mechanical Engineering, Newark College of Engineering, Newark, N. J. F. D. Carvin, S. Fishman.

# CIVIL ENGINEERING DIVISION

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## COMMITTEES: THEIR PURPOSES, PROGRAMS AND OBJECTIVES

BY FRANK KEREKES
Professor of Structural Engineering, Iowa State College

The Civil Engineering Division was conceived, authorized, and created at the Cornell Convention of the Society in June 1934. To-day its Atlanta Conference is history commemorating the presentation of twenty-four papers, the stimulation of vital interest in certain well defined educational trends, and the realization and crystallization of the vision of Professor L. E. Conrad, who first suggested the advantages of forming a division.

The primary purpose behind the formation of committees within the Division is to establish working units which will devote their efforts to an active and continual consideration of the problems arising in specific related fields of civil engineering education. At the earliest stages of organization it was evident that without committees the Executive Council of the Division would be nothing more than a committee with another name. The secondary, but important, purposes are: to discover leaders, to give interested and competent men opportunities for development and expression, and to combine the aspirations of younger teachers with the experience of the more mature educators. To-day there are on the various committees in the C.E. Division 59 members from 41 institutions in 20 states. Certainly, we can look with confidence and assurance for future accomplishments.

The programs of these committees are varied. Even a casual glimpse through my files reveals a picture of many men coördinating their thought and effort toward the solution of well defined current problems. The *Educational Policy and Teaching Methods* Committee plans to study special methods relating to courses that are: (*a*) Basic, (*b*) Applied, (*c*) Informational and (*d*) Manipulative. The *Structural* Committee, the last to be organized, is considering (*a*) the Madison Conference program and (*b*) the circulation of unpublished research in abstracted mimeographed form. The *Sanitary* and *Applied Hydraulics* Committees are combining to secure hydrology data in a form sufficiently comprehensive and suitable for instructional purposes. The *Transportation* Committee is well on its way in a survey of courses in transportation. The Committee on *Construction Education* under the same chairman is working comparatively with a similar committee of the American Society of Civil Engineers. Already a great deal of work has been carried on in the study of the general field of construction as it affects educational institutions. The *Foundation and Soil Mechanics* Committee is making a survey of the established courses in this field and preparing to coöperate in the plans for the International Congress on Soil Mechanics to be held at Harvard University in June 1936. The *Geodesy and Surveying* Committee is making a study of Summer Camps for the teaching of surveying.

The principal objectives of these eight committees may well be alike: First, to coördinate their activities through the agency of the Executive Council of the C. E. Division. Second, to sponsor future C. E. Conference programs. Third, to follow developments in specific fields of civil engineering education. Fourth, to encourage new men in the participation of the work of the Society and the Division. Fifth, to act as a clearing house for related current information relative to teaching methods, course contents, and creative research. And sixth, to stimulate interest in and enthusiasm for a healthy spirit of mutual cooperation among teachers of civil engineering.

# The T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE DIVISION OF ENGINEERING DRAWING

FREDERIC G. HIGBEE, EDITOR

*Syllabus on Drawing.* An interesting and comprehensive syllabus for drawing courses in high schools has been issued by the University of Illinois. Of especial interest to teachers of Engineering Drawing is the comprehensive bibliography of more than thirty pages prepared with the coöperation of a committee of the Engineering Drawing Division. Copies of the syllabus may be obtained from Dept. of Engineering Drawing, University of Illinois.

*What is your pet "peeve"?* One teacher of drawing states that his two pet peeves are the unwarranted and persistent use of the word "printing" for lettering; and the use of the term "mechanical" drawing. Recently one hundred students were asked if "mechanical" drawing meant drawings of machines. Forty answered yes. The term "engineering" drawing is so much more satisfactory and descriptive that "mechanical" should be dropped entirely.

*Drafting Room Illumination.* Recent studies in illumination by a division of the American Institute of Electrical Engineers have set up some new standards and have caused to be developed new fixtures. Teachers of drawing have a serious responsibility in respect to the actual amount of light students have on the drafting table and how free this table top is from shadows. The lack of proper illumination on the tables in some college drafting rooms is shocking; the illumination may easily be checked and when found to be below standard should be corrected.

*Office Personality.* Teachers of engineering drawing are constantly stressing orderliness in thinking and working; neatness and precision are by-words of daily use. What impressions do students get when they enter staff offices of engineering drawing departments? Can there be any argument that the "personality" of these offices should reflect and exemplify the teaching?

## BOOK REVIEWS

*Design of Concrete Structures.* LEONARD C. URQUEHART AND CHARLES E. O'ROURKE. McGraw-Hill Book Company. 1935.

This book should be quite applicable for use in undergraduate courses in civil engineering. It builds the foundation of concrete design for the elementary student, as well as showing the application of these principals in practice.

Besides the design of the various elements of concrete structures, the book gives a fairly complete description of the physical and chemical behaviour of concrete. The method of proportioning aggregates and of obtaining the water-cement ratio for mixing the concrete for varied purposes is outlined. The development of the general design formulas as well as the application of the transformed-section method can be readily understood by students having a knowledge of "strength of materials" and "mechanics."

This revised edition has been organized to include the latest practices in plain and reinforced concrete design. The section describing the action of continuous frames has been more completely covered than it was in the last edition. Multiple-column footings and the method of equalizing settlement have been added, as well as explanations for the newer types of floor systems. Design of concrete highway bridges has also been included, paying particular attention to the necessary construction details.

GEORGE R. GRAY

*Factory Organization and Administration.* HUGO DIEMER. 412 pages. McGraw-Hill Book Co.

In bringing out this book, Colonel Diemer has carefully revised the preceding or fourth edition, which came out in 1925. "Of making many books there is no end," and the field covered by this book has served to inspire a great many writers. Then books must necessarily develop considerably, but Colonel Diemer seems to have covered the ground in a most satisfactory and original manner, and was one of the pioneers in the field, the first edition having come out in 1910 when he was head of the then new and then quite original department of industrial engineering at the Pennsylvania State College.

One advantage of this work lies in the fact that, while the author has long been connected with the teaching profession, he has

also had wide experience as a successful practicing engineer. In the preface to his first edition, he states that he intends the book "to be of service to offices of manufacturing corporations, works managers, superintendents, accountants and the heads of such departments as purchasing, stores, cost and production; and in fact to all employees of manufacturing corporations who desire to acquire a comprehensive group of the problems treated." Secondarily, it was written in such form as to provide a comprehensive text for students in engineering schools.

To the mind of this reviewer, who has also pretty evenly divided his professional work between teaching and commercial practice, the ideal text-book is one written on the author's actual experience in applying the principles he attempts to teach. Such a book Colonel Diemer has produced. He has given a number of forms and other case material, but has been careful to warn the reader that they by no means are meant to illustrate "the 'one best way,' but are typical of modern practice as exemplifying the coördination of departments, accounts and systems."

In conclusion, it is this reviewer's opinion that Colonel Diemer has given a new lease of life to a book that was already a classic in its field, and brought it thoroughly in time with present day development and thought.

WM. STEWART AYARS

*Descriptive Geometry.* FRANK W. BUBB. New York, The Macmillan Company, 1935. xv + 234 pages. $2.50.

Probably every one who deals with engineering students has been told, from time to time, that the subject known as Descriptive Geometry is simply beyond mortal comprehension. Professor Bubb states the case very clearly in the preface to his book:

"The clinical history of the student who has been taught by the traditional method is curious. It is universally observed that he muddles along in a state of confusion and dismay until near the end of his course. Suddenly the course clears up, becomes easy, and the student has no further difficulty. However, by this time (and there are many who never reach this 'crisis') he has nearly completed his course and just when he has reached the stage where he might do some effective work he is through with the subject. Consequently, he derives little benefit from his efforts."

The author interprets the "crisis" as indicating that the student has finally come to see the three dimensional significance of his two dimensional drawings. There are two aspects of Descriptive Geometry: figures and constructions in space, and methods of representing them on the plane. If the student were taught the space

part of the subject first he should have no trouble in understanding it from the start. This book is written in accordance with this belief.

The development of the subject follows a very definite plan. All constructions in space are analyzed in terms of seven "Fundamental Space Operations" which the student is taught to master. He is then taught to draw them out by means of certain "Drawing Board Constructions." This is certainly sound logic and it looks like good pedagogy. The student is taught to analyze every problem in space before he attempts to draw it out on paper.

The book includes more material than can be covered in the usual course. There are about 1000 problems, including a list of "challenge problems" at the end of the book. The notation is essentially that of Th. Olivier, which is widely used. It would no doubt be unreasonable to expect all teachers and writers to use precisely the same notation, but the reviewer believes that they could at least agree to represent points, lines, and planes by capital italic, small italic, and small Greek letters respectively, as is done in this book, since this notation is so widely used in other branches of geometry. Both first and third quadrant projection are used and auxiliary views are emphasized. The figures are numerous and good.

This textbook is carefully planned and well written and should help the cause of better teaching in Descriptive Geometry.

WM. I. MILLER

*Surveying.* HARRY BOUCHARD, Assistant Professor of Geodesy and Surveying, University of Michigan. International Textbook Co., Scranton, Penna. June, 1935.

This new text on surveying has a number of good features. The illustrations are excellent. The presentation is very good. Professor Bouchard takes the trouble to explain the idea he is presenting in plain language and in logical order. The introductory sentences to most paragraphs are excellent.

The arrangement of the book is such that it may be used in a short course in surveying with chapter assignments in regular order, the first seven chapters covering the fundamental principles. The remainder of the nineteen chapters makes the book a complete surveying text. The idea of reserving a separate chapter toward the end of the book for the adjustment of instruments fits very well into the arrangement that makes this text suitable for both a short course or a long course in surveying.

The tables would be better if the logarithms of numbers were to six places instead of to five places; they would then match the logarithmic functions of angles.

W. IRWIN SHORT

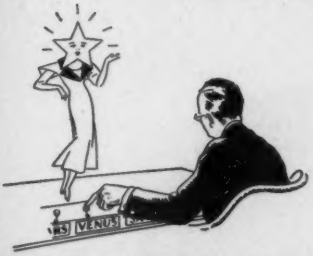
The new third edition of Williams & Homerberg, "Principles of Metallography," which has just been published by McGraw-Hill, as a volume in The International Chemical Series, maintains the high quality of the earlier editions, and brings the subject matter of the text up to date. The book contains 270 5½" × 8" pages of text and illustrations, and an additional 43 pages of appendices, indices, etc.

The chapter on "The Simple Alloy Diagram" and that on "The Macroscopic Examination of Steel" are of about the same length as in the second edition. The other chapters—"The Alloy Diagram and its Meaning," "The Nonferrous Alloys of Technical Importance," "Iron and Steel," and "Laboratory Methods"—have all been appreciably extended. Much of the text has been carefully rewritten. Good appendices give a list of references to more specialized literature, a list of industrial alloys, and etching reagents for metallographic use.

This is the most satisfactory brief textbook I know of on metallography for the engineer not specializing in metallurgy, and for the general reader, and is an excellent introductory text for students planning further study in metallography. The statements are clear and well written, the arrangement and illustrations are good, and the material well chosen to cover the field.

S. L. GOODALE.

# G-E *Campus News*




## CELESTIAL PUSH-BUTTON CONTROL

HEAVENLY bodies a million times fainter than the faintest star the eye can see unaided will be brought to the earth for inspection and photography at the touch of an electric push button when the McDonald Observatory on Mt. Locke in western Texas is placed in operation. The observatory building itself is almost completed, but the technicians of the Warner and Swasey Company at Cleveland are "making haste slowly" with the polishing of the 82-inch reflecting mirror. They estimate that another 12 or 18 months will be needed before the mirror is ready for installation. The 44 tons of moving parts of the telescope will be at the command of a single individual, who will be able to take his stand upon an observing bridge and virtually order the stars to parade before him. The motors and complete electrical control to make this possible have been manufactured for the builders of the telescope by General Electric.

## EDITORIAL BOUQUET

IT IS very pleasant to have people say nice things about one. The pleasure is curiously heightened, however, when the nice things are said in a roundabout way—never intended directly to reach one's ears. General Electric recently was honored in such a manner on the editorial page of the Spokane, Washington, *Chronicle*, and the Company is still basking in the warmth of the glow generated. The editorial, in part, read as follows:

"An exposition at which inventors of the Pacific Northwest will display their work will be held next month in Portland.

"It will probably be a revelation to those who see it. Most persons find it hard to think of great men coming from 'near at home.' When one speaks of inventors or scientists, the Northwest citizen thinks of the General Electric laboratories, or of observatories in California, or clinics in Vienna. . . ."

## VOICES FROM THE SKY

WHEN the Whiteface Memorial Highway—a road leading to the summit of the 5000-foot Whiteface mountain in the heart of the Adirondacks—was dedicated this autumn, voices came from down from the sky on a beam of light. There was nothing mystical about this performance, however. The beam of light came from a 24-inch G-E searchlight on the summit of the mountain. The voices were those of President Franklin Roosevelt and New York's Governor Herbert Lehman.

President Roosevelt's words, dedicating the highway, were carried on the light beam seven miles from the mountain to the crowd at the Lake Placid airport. Governor Lehman had spoken over the light beam the night before. He was so interested that, after the dedication ceremonies were finished, he spoke again to demonstrate the equipment to the members of his family. Both night and day demonstrations were successful, although once or twice during the day the words faded to faintness when small clouds floated by the mountain top and partially obscured the light beam.

Two-way communication was carried on by means of short-wave radio equipment located at the airport. G-E engineers made the special installation.

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"It seems to me that the sequence of his chapters is much better than any other text that I have seen, as it follows the procedure in the field that a man might follow as he enters upon the work of a surveying crew."

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"To date I have covered the first two chapters and nothing could fill the bill any better. It presents the subject in a simple, clear and concise manner without making it necessary for us to skip all over for an assignment which has been the main difficulty."

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—A. LIGHTHALL, *Assistant Professor of Civil Engineering, University of British Columbia*

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